CIMFORM®
GRINDING WHEEL APPLICATION GUIDE

PLAINTIFF'S EXHIBIT

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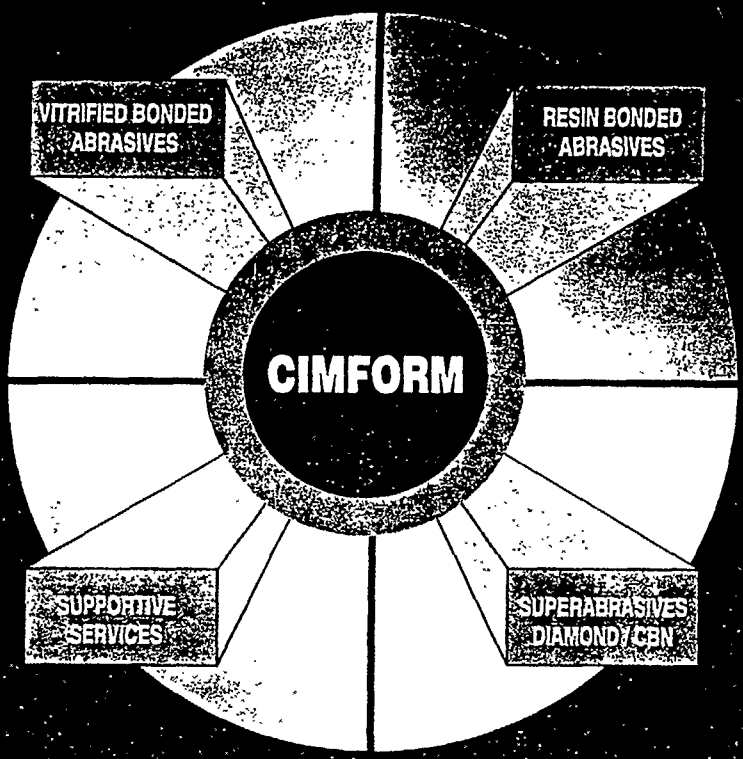

Centerless Grinding
Centertype Grinding
Camshaft Grinding
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Precision Roll Grinding
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Internal Grinding
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FOR ALL YOUR GRINDING NEEDS

Count on Milacron.

MIL 000022

Introduction

Cincinnati Milacron leads the metalworking industry in developing superior solutions to grinding and metalworking applications.

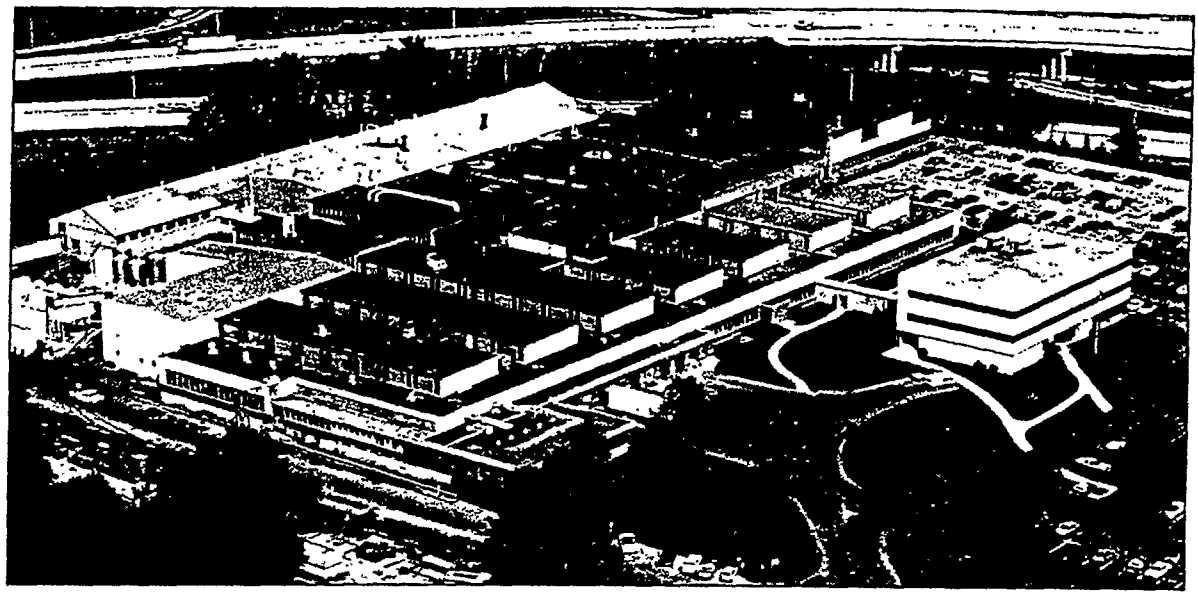
The Consumable Products Division uses a total systems approach to bring application expertise to its complete line of metalworking products.

The information that you will find in this Application Guide will help remove the curtain of mystery that surrounds many grinding applications.

Types of grinding are highlighted in this guide, ranging from sharpening carbide tipped cutters to snag grinding huge billets. Generally each grinding section contains starting grade recommendations, machine data, wheel sizes, and trouble shooting.

Your daily use of this publication will quickly familiarize you with Cincinnati Milacron products, and shed some light on solving problems you may face every day.

Mission Statement



The Consumable Products Division of Cincinnati Milacron will be the recognized global leader in the development, manufacture and marketing of abrasive and metalworking fluid products and services for the metalworking industry.

Using the core strategy of leadership we will endeavor to establish an environment of mutual respect and trust between our employees, customers and suppliers. We will use the principles of innovation and continuous improvement to consistently exceed customer expectations, and be the global supplier of choice.

We will reach for growth and profitability in our business while providing growth and opportunity for each of our employees.

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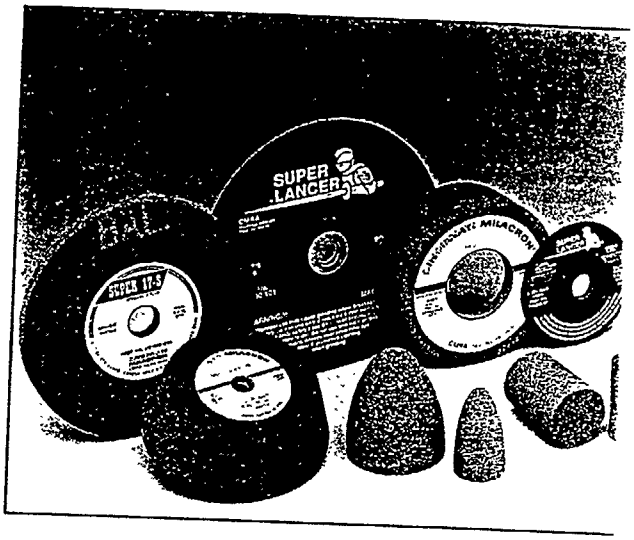
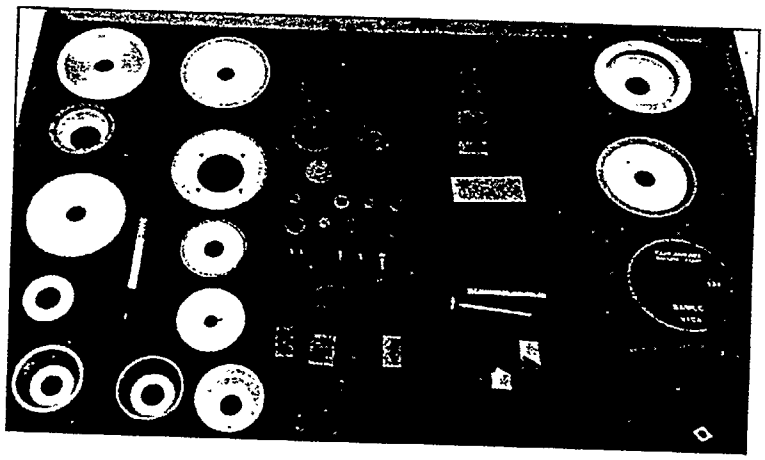
1 General Information





Product Availability

In most grinding wheel specifications, there are only five items needed for a complete grinding wheel grade. These are:

1. Abrasive
2. Size of abrasive (grit size)
3. Hardness
4. Structure
5. Bond (vitrified, resinoid, and special). These will be discussed in depth in the subsequent section.

Abrasive

The abrasive used for an operation is usually determined by the material to be ground. There are four general categories of abrasives:

A. Aluminum Oxide
B. Silicon Carbide
C. Diamond
D. Cubic Boron Nitride (CBN)

Aluminum oxide is used to grind high tensile strength material such as carbon steel, alloy steel, annealed malleable iron, etc. Silicon Carbide is used to grind low tensile strength materials such as gray iron, chilled iron, bronze, aluminum, copper, etc. Aluminum oxide and silicon carbide are considered conventional abrasives. Diamond is used to grind extremely hard non-ferrous material such as tungsten carbide and ceramics. CBN is used to grind hardened tool steels such as M series or T series. Diamond and CBN are considered superabrasives.

To understand the remainder of this section, a knowledge of the term of "friability" is needed. "Friability" is the ability of an abrasive grain to fracture under grinding stress. More friable abrasives are more easily fractured during grinding and thus cut cooler, but wheels made of these abrasives generally do not last as long.

A. Aluminum Oxide Abrasive

2A - Tough aluminum oxide grain with a titanium impurity to impart toughness; used for heavy duty work (blue color).

4A - Semi-friable grain - has a sodium impurity to impart special fracture capabilities (pinkish beige color).

12A - Semi-friable grain - has a chromium impurity to impart special fracture capabilities (pink color). Recommended for some heat sensitive steel alloys, special alloys, and high chrome alloys.

9A - Pure aluminum oxide, very friable grain (white color). This abrasive is recommended for tool steels and other heat sensitive steels.

97A - A combination of 2A and 9A to form a semi-friable wheel used for more heat sensitive steels, or where burn with 2A abrasive is a problem.

2A and 97A are by far the most popular abrasives for most precision grinding applications.

29A - A higher friability mixture of 2A-9A (light gray).

WA - White friable aluminum oxide

JA - A blend of one friable and one semi-friable aluminum oxide.

LA - Similar to JA.

FA - Tough aluminum oxide.

13A - Pink semi-friable aluminum oxide.

HA - Semi-tough - same as 97A.

See page 1-31 for Ceramic Abrasive designations.

B. Silicon Carbide

6C - Black silicon carbide - used for grinding non-ferrous materials and gray or cast irons.

5C - Green silicon carbide - used for heat-sensitive, non-ferrous materials.

7C - Combination of 5C and 6C.

6C is the most popular grain used for silicon carbide applications.

Combination aluminum oxide and silicon carbide - combination grains C2A, C4A, and C12A - are available in resin-bonded wheels. These combinations of abrasive types are used for special alloys and materials.

C. Diamond

MD - Uncoated medium friability diamond for general heat sensitive carbides.

CMD - Nickel coated medium friability diamond for general uses.

AMD - Copper coated medium friability diamond for day grinding applications.

DMD - Nickel coated tough diamond for carbide-steel combinations.

EMD - Nickel coated friable diamond for carbide grinding (no steel).

D. Cubic Boron Nitride

1BN - Nickel coated CBN used in resin bonds.

2BN - Uncoated CBN used in vitrified wheels.

Grit Size

Conventional abrasives are available from coarse grit 24 to fine grit 220 mesh. Superabrasives are generally available from 60 grit to 1000 grit.

Grades

The grade of the wheel specifies the relative amount of bond in the wheel. An M grade wheel has more bond than an I grade (M will act harder).

Soft grades are used on:

1. Large stock removal operations, (i.e., surface grind).
2. Large area of contact.
3. hard materials.

Hard grades are used on:

1. Low stock removal operations (finish).
2. Small areas of contact.
3. Soft materials.

Bonds

There are two generic types of bonds for precision grinding: resinoid and vitrified. Resinoid bonds are grinding wheel bonds comprised of a plastic bonding system. Vitrified bonds are grinding wheel bonds comprised of glass-like materials. Though there are no clear-cut distinctions between where resinoid and vitrified wheels are used, resinoid wheels are generally used when the wheel has to absorb some shock or the operation requires that no dressing is desired throughout the useful life of the wheel. Vitrified bonds are used for form holding and high precision operations.

Resinoid Bonds

The breakdown of resin wheels in grinding is primarily from heat. Apparently the breakdown from pressure plays only a minor role in resins; however, pressure is a major factor in vitrified breakdown. This (in part, at least) explains why these bonds do not act the same in grinding grade for grade, and why the grade patterns cannot be compared one with the other. To further the confusion, competitive resinoid grading systems and our own agree less among themselves than they do in vitrified. For this reason it is seldom wise to rely too heavily on competitive gradings. Although we do not agree with competition, we do have a regular progression in hardness from grade to grade which is not generally common with other manufacturers.

Resin bonds in general have a much higher resistance to thermal shock than do vitrified and are therefore to be used on all dry, high stock removal operations to the exclusion of vitrified bond.

Resin bonds are better able to absorb mechanical vibr tions and are for this reason preferred in many finishin operations where fine grain wheels are used (120 and finer). The coarser grain sizes are usually avoided in fi ishing because of the tendency of resins to "fish tail", leaving deep scratches in the surface.

There is another important difference between resin ar vitrified bonds in application. It is usually easy to deter· mine the hard or soft action of a vitrified wheel; howeve this is not always true of resin. A resin wheel will often act soft when it is in fact too hard. This stems from the fact that resins break down from heat. The harder the wheel, the more heat developed - and hence more breakdown. There is no easy way to analyze this type c problem except to say that if several wheels have been tried, each harder in grade than the preceding wheel, and all act soft, it is often wise to try grades softer than the softest grade tried.

Unlike vitrified bond wheels, resin bond wheels cannot be checked for cracks by ringing them with a mallet.All resin wheels should be given a careful visual inspectior before mounting.

Wet or Dry Grinding

Resin bond wheels give best results when the bond is selected for either wet or dry grinding. This is important because resins are not waterproof. Some have better moisture resistance; others have better heat resistance. Precision Cincinnati resins B2, B80, B90 and BWK should be used wet.

B2 - General purpose resinoid bond system used in moderate to light operations. Usually used for wet grinding. this bond has high moisture but low heat resistance and should be used on applications where any kind of cutting fluid is used.

B80 - General purpose resinoid bond used in mode ate to heavy grinding activity. B80 is also designed for wet grinding where there is high stock removal and high feed rates. Usually recommended in the higher grade range - P6, Q6, R6, S6, etc.

B90 - Another general purpose resin bond recommended for both heavy duty and precision grinding. Although somewhat more resilient than B80, usually produces higher "G" rations and better reproducibility

BWK - Special purpose resinoid bond.

Vitrified Bonds

VFM - General purpose bond system for precision grinding. Used with aluminum oxide only.

VRW - General purpose bond system for precision grinding with excellent form holding capabilities. Used with aluminum oxide abrasive only.

VQC - General purpose bond system for high production centerless, large centertype, and microcentric (available in 2A and 97A abrasives only).

VA - A slightly softer acting vitrified bond used in grinding large diameter, thin wall, face grinding, and flat parts.

V4, VC, VF - Additional vitrified bonds used in creep-feed products and some surface grinding applications.

VC2 and VF2 - The "2" indicates the wheel is 1/2 grade harder than standard.

VL - Bond system for surface grinding. Used with aluminum oxide abrasive only.

VSC - Bond used with silicon carbide abrasive.

Diamond Bond

B - General purpose bond system designed for MD, CMD, and EMD type diamond.

B5 - Dry grinding bond system designed for AMD type diamond.

B6 - Special bond system designed for DMD type diamond for carbide steel application.

BY - A high quality resin bond used in grinding non-ferrous materials.

CBN Bonds

B4 - General purpose grinding bond designed for 1BN abrasive.

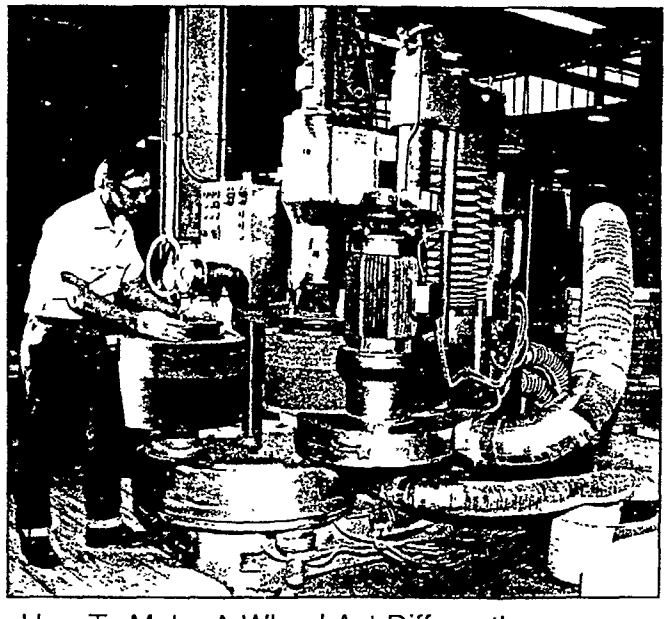
B7 - Toolroom grinding system designed for 1BN abrasive.

Marathon Products

VHA - Vitrified bond system designed for internal and notch grinding where aluminum oxide would normally be used.

VHC - Vitrified bond system designed for internal or notch grinding where silicon carbide abrasive would normally be used.

VMA, VEA - Vitrified bonds used in the open structure Marathon products.



How To Make A Wheel Act Differently

Harder	Softer
Decrease infeed rate	Increase infeed rate
Decrease traverse speed	Increase traverse speed
Decrease work speed	Increase work speed
Decrease thrufeed rate	Increase thrufeed rate

Additional information for superabrasives is in Section 12.

General Information.

Plastic Bushing

Bushing Designation	Thickness	ID (inches)	Reduced ID Sizes (inches)
NB1 (1)	1/2"	1,3/4,5/8	3/4,5/8,1/2
NB2	3/4"	1,3/4,5/8	3/4,5/8,1/2
NB3	1"	1,3/4,5/8	3/4,5/8,1/2
SB4 (2)	1/4" and thicker	1	3/8
SB5	1/4" and thicker	1	1/2
SB6	1/4" and thicker	1	5/8
SB7	1/4" and thicker	1	3/4
SB8	1/4" and thicker	1 1/4	1/2
SB9	1/4" and thicker	1 1/4	5/8
SB10	1/4" and thicker	1 1/4	3/4
SB11	1/4" and thicker	1 1/4	7/8
SB12	1/4" and thicker	1 1/4	1

Metric and Decimal Equivalents of Common Fractions

Fractions of an Inch		Decimals of an Inch	Milli-meters	Fractions of an Inch		Decimals of an Inch	Milli-meters
	1/64	.0156	0.397		33/64	.5158	13.097
1/32		.0313	0.794	17/32		.5313	13.494
	3/64	.0469	1.919		35/64	.5469	13.891
1/16		.0625	1 588	9/16		.5625	14.287
	5/64	.0781	1.985		37/64	.5781	14.684
3/32		.0938	2.381	19/32		.5938	15.081
	7/64	.1094	2.778		39/64	.6094	15.478
1/8		.1250	3.175	5/8		.6250	15.875
	9/64	.1406	3.572		41/64	.6406	16.272
5/32		.1563	3.969	21/32		.6563	16.688
	11/64	.1719	4.366		43/64	.6719	17.085
3/16		.1875	4.762	11/16		.6875	17.462
	13/64	.2031	5.159		45/64	.7031	17.859
7/32		.2188	5.556	23/32		.7188	18.256
	15/64	.2344	5.953		47/64	.7344	18.653
1/4		.2500	6.350	3/4		.7500	19.050
	17/64	.2656	6.747		49/64	.7645	19.447
9/32		.2813	7.144	25/32		.7813	19.843
	19/64	.2969	7.541		51/64	.7969	20.240
5/16		.3135	7.937	13/16		.8125	20.637
	21/64	.3281	8.334		53/64	.8281	21.034
11/32		.3438	8.731	27/32		.8438	21.430
	23/64	.3594	9.126		55/64	.8594	21.827
3/8		.3750	9.525	7/8		.8750	22.224
	25/64	3906	9.922		57/64	.8906	22.621
13/32		.4063	10.319	29/32		.9063	23.018
	27/64	.4219	10.716		59/64	.9219	23.415
7/16		.4375	11.112	15/16		.9375	23.812
	29/64	.4531	11.509		61/64	.9531	24.209
15/32		.4688	11.906	31/32		.9688	24.606
	31/64	.4844	12.303		63/64	.9844	25.003
1/2		.5000	12.700	1		1.0000	25.400

Plastic Blotter Availability

	DIAMETER	HOLE	THICKNESS	INVENTORY	MINIMUM ORDER QTY	NET CONSUMER SELL PER PC
4061J	8 1/2"	6 1/8"	.020	YES	100 PCS	.86
4496G	14 3/4"	12 1/8"	.014	NO	100 PCS	3.16
4061L	14 3/4"	12 1/8"	.020	YES	50 PCS	1.84
44247	17"	12 1/8"	.014	NO	100 PCS	5 20
4061M	17"	12 1/8"	020	YES	50 PCS	3.76
4494B	17 3/4"	12.090	.020	NO	100 PCS	3 84
4061G	20 1/8"	16 1/8"	.014	NO	100 PCS	6.02
4061N	20 1/4"	16 1/8"	.020	YES	50 PCS	4.43
6447J	8 1/4"	5 1/8"	.020	YES	100 PCS	86
4817R	11 1/8"	8 1/8"	020	YES	100 PCS	3.16
7280R	24 1/4"	20 1/4"	015		100 PCS	4 92
5281G	12 3/4"	10 1/8"	020	NO	100 PCS	91
81181	13 1/8"	10 1/8"	020	NO	100 PCS	91
5166N	13"	10"	.020	NO	100 PCS	91

Metric Conversions

MM to Inches		Inches to MM	
MM	Inches	Inches	MM
3	.118	1/8	3.17
6	.236	1/4	6.35
8	.315	5/16	7.94
10	.393	3/8	9.52
13	.511	1/2	12.70
16	.629	5/8	15.87
20	.787	3/4	19.05
25	.984	1	25.40
32	1.259	1-1/4	31.75
40	1.574	1-1/2	38.10
50	1.968	2	50.80
63	2.480	2-1/2	63.50
80	3.149	3	76.20
100	3.937	4	101.60
125	4.921	5	127.00
150	5.905	6	152.39
180	7.086	7	177.79
200	7.874	8	203.19
230	9.055	9	228.59
250	9.842	10	253.99
300	11.811	12	304.79
350	13.779	14	355.59
400	15.748	16	406.38
450	17.716	18	457.18
500	19.685	20	507.98
550	21.653	22	558.78
600	23.622	24	609.58
650	25.590	26	680.37
700	27.559	28	711.17
750	29.527	30	761 97
800	31.496	32	812.77
850	33.464	34	863.57
900	35.433	36	914.36
950	37.401	38	965.16
1000	39.371	40	1015.96
1050	41.339	42	1066.76
1100	43.308	44	1117.56
1150	45.276	46	1168.35
1200	47.254	48	1219.15
1300	51.182	50	1269.95
1500	59.056	60	1523.94
1800	70.867	70	1777 93

Metric Conversions

SFPM to M/Sec		M/Sec to SFPM	
SFPM	M/Sec	M/Sec	SFPM
1000	5.080	10	1969
2000	10.159	12	2362
3000	15.239	15	2953
3500	17.779	20	3937
4000	20.319	22	4331
4500	22.859	25	4922
5000	25.399	28	5512
5500	27.938	30	5906
6000	30.478	33	6496
6500	33.018	35	6890
7000	35.558	38	7481
7500	38 098	40	7874
8000	40.638	43	8465
8500	43.177	45	8859
9000	45.717	48	9449
10000	50.797	60	11812
10500	53.337	63	12402
11000	55.877	80	15749
11500	58.417	100	19686
1200	.60.956		
12500	63.496		
13000	66.036		
13500	68.576		
14000	71.116		
14500	73.656		
15000	76.196		
15500	78.735		
16000	81.275		

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Availability of Permanent Type Bushings

1. Lead bushings are no longer available except as special order on the A80-R2-R regulating wheels.

2. Current I.D. treatments are as follows:

Sized hole (S.H.) - a special precision tool coats the hole with a liquid plastic which hardens to a tough, precise hole.

Vitrobond bush - a proprietary blend of fillers, molten sulfur and fiberglass is cast into the I.D. This forms a tough, very smooth I.D.

Ground hole - I.D. ground to size.

Vitrified Bonds

VQC - our latest development in vitrified bonds designed as a non-premium bond for improving part quality.

VRW - high performance bond for aluminum oxide grain designed for durability in high production applications.

VFM - general purpose bond for aluminum oxide grain; designed for form holding.

VSC - general purpose bond for silicon carbide abrasives.

VA -a slightly softer acting vitrified bond used in grinding large diameter, thin wall, face grinding, and flat parts.

V, VC, VF - additional vitrified bonds used in creepfeed products and some surface grinding applications.

VC2 and **VF2** - the "2" indicates the wheel is 1/2 grade harder than standard.

VL - bond for aluminum oxide segments and surface grinding wheels.

V5, V6, V7, V10 - bond for valve seat wheels and mounted wheels.

VFME1 - a vitrified bond for use in special regulating wheel applications.

VSA - A high quality vitrified bond developed for use with MSB abrasives.

V8 - Additional vitrified bond for use with silicon carbide grain.

3. Wheel bushing availability

   A. For small holes up to 4"

      - first preference is sized hole (S.H.)
      - ground hole is not desirable but can be made available

      For cup wheels the first choice is sized hole

   B. For larger I.D.'s over 4"

      - the vitrobond bush is available for 5", 12", and 20" I.D. holes. Most (but not all) wheel O.D. sizes and thicknesses can be vitrobond bushed. Minimum wheel thickness is generally 2"..

Resin Bonds

B2 - general purpose bond for wet grinding and cutoff wheels.

B80 - a high strength resin bond developed mainly for high stock removal.

BB - bond for mounted wheels.

B8 - warm pressed bond for severe cutoff operations.

BF9 - reinforced bond for cutoff wheels.

Special Resilient Bonds

BR - special rubber-resin bond for regulating wheels.

BWK - special purpose bond..

B90 - another general purpose resin bond recommended for both heavy duty and precision grinding. Although somewhat more resilient than B80 usually produces higher "G"-rations and better reproducibility.

BA, BC, BF, BH - General purpose resin bonds for use in Grades F-S.

B254 - Higher strength bonds used in both precision and snagging operations.

B320 - Developed for roll grinding and cut-off.

B9 - Cold presed cut-off bond.

BL3206 - Hot pressed resin bond.

E - Shellac bond used in roll grinding.

Rubber Bonds

R - general purpose rubber bond.

CIMFORM® GRINDING WHEELS MARKING CHART ON PAGE 1-36

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VQC Product Availability

Diameter	Thickness		I.D.							
	Min.	Max.	5"	8"	9"	10"	12"	16"	18"	20"
14	3/8	4	X	X						
16	3/8	4	X	X	X	X				
18	3/8	4			X	X				
20	3/8	10				X	X			
22	1/2	4				X	X			
24	1/2	20					X	X	X	
26	3/4	8					X		X	
30	3/4	10					X	X	X	X
36	7/8	10					X	X	X	X
42	7/8	6					X			X

Grain Types - 2A, 29A, 97A, 12A
Grit Size - 46, 54, 60, 70, 80, 90, 100, and 120
Grades - I through N
Structure - None
Shapes - All

Not Available - Multigrades, Bias Wheels
Standard Maximum Operating Speed - 6500 SFPM for Types 1, 5 and 7. Higher operating speeds should be noted on wheel orders. If approved an "E" will be added to the wheel grade to indicate overspeed operation.

VFM CIMFORM® Wheel Availability

Aluminum Oxide Vitrified Wheels and Segments

Grit Sizes

Structure	2A	4A	9A	12A	97A	29A
4 (dense) structure	36-220	36-220	36-220	36-220	36-220	36-220
6 (medium) structure	24-120	24-120	24-120	24-120	24-120	24-120
10 (open) structure	24-100	24-100	24-100	24-100	24-100	24-100

Grades

	Grit Size									
	Coarse		Medium				Fine			
Structure and wheel size	24	30	36	46	54 to 60	70 to 80	90 to 100	120 to 150	180	220
4 structure 1/4" to 30" OD 36" OD 42" OD			H-R H-R H-R	H-R H-R H-R	G-R G-R G-R	G-S G-S G-S	F-S F-R F-Q	F-S F-Q F-P	F-R F-P F-O	F-R F-P F-O
6 structure wheels & segments 1/4" to 42" wheel OD	H-N	G-N	G-N	G-N	F-N	F-N	F-M	120 F-M		
10 structure wheels & segments Min. wheel OD 6"	E-K	D-K	D-K	D-K	D-K	D-K	D-K			

*Standard Maximum Wheel Speeds

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	GRIT SIZE & WHEEL GRADE					
	46 & Coarser			54 & Finer		
	D	E	F & Harder	E & Softer	F	G & Harder
Wheel Type	SFPM			SFPM		
6 & 11	4500	5000	6000	4500	5000	6000
2	5000	5500	6000	5000	5500	6000
other	5500	6000	6500	5500	6000	6500

*See special operating speed section for exceptions.

VRW SUPER CIMFORM® Wheel Availability

VRW is available in 2A, 4A, 9A, 12A , 29A and 97A grain types, 4 and 6 structures in wheels only, 1/4" OD and up to 42" OD.

4 STRUCTURE	
GRAIN SIZE	GRADES
36 - 46	H - S
54 - 80	G - S
* 90 - 120	F - Q
*150 - 220	F - N
*90 grit & finer, 4 structure wheels over 15 inches thick must be ordered in two sections.	

6 STRUCTURE**	
GRAIN SIZE	GRADES
36	H - M
46	G - M
* 54 - 120	F - M
**6 structure MAXIMUM THICKNESS is 10½" in one piece.	

	Grit size and wheel grade		
	36 & Finer		
Wheel type	E & softer	F - G	H & harder
	SFPM		
6 & 11	4500	5000	6000
2	5000	5500	6000
other	5500	6000	6500

NOTE: D2 treatment only

If type 7 web thickness is less than 40%, use speed for type 6 & add "E" for overspeed.

**See Special Operating Speed section for exceptions.*

Resinoid Wheel - B90 Bond Availability

Grades: F - T
Structure: 6-9-11-13-15
Grain Sizes: 36 - 150
Variable Densities: 6/4 - 9/5
Grain Types: 2A, 4A, 9A, 12A, 29A, 97A, 5C, 6C, C2A, C4A, C12A

Max. Operating Speed: *9500 SFPM
*L Grade and softer, 36 grit size = 8000 SFPM Max.

Maximum thickness 10" for all grades

Resinoid Wheels
B2 Bond - General Purpose
(Except Cut-Off)

Abrasive Type	Abrasive Grit Size
2A. 4A. 9A. 12A	24-220
*97A	24-220
5C	24-220
6C	24-220
*7C	24-220
CA	24-36
C2A, C4A, C9A, C12A	24-220
29A, MSB	24-220

**97A, 29A and 7C grain available in "1" grain combination only*

Additional Resin Bonds For Precision and Non-Precision Grinding

Bond	Usage Range	Purpose
BA BC BF BH	F-N L-Q O-R Q-S	General Purpose Range From A to H (Hard)
B254 B5	P-W R-W	High strength bonds used for both precision and snagging operations
B320	F-P	Coolant resistant bond. Used for roll grinding & soft grade cut-off
B9	N-X	Basic cold-pressed cut-off bond
BL6823 BL3206 BZ243 BL1830	X	Softest hot-pressed bond to Hardest
E		Shellac bond

MIL 000033

VRW Product Availability

Abrasive Types: 9A, 4A, 12A, 29A, 97A, 2A
Abrasive Sizes: 36-220. See Table for Grade Availability
Wheel Thickness: 4 Structure - 15" Maximum
6 Structure - 10½" Maximum
10 Structure - 6" Maximum

Structure and Wheel Size	Grain Size					
	36	46	54-80	90, 100	120	150-220
4 Structure 1/4" Through 42" O.D.	H-S	H-S	G-S	F-Q	F-Q	F-N
6 Structure 1/4" through 42" O.D.	H-M	G-M	F-M	F-M	F-M	
10 Structure 4" through 30"	E-K	E-K	E-K	E-K		

*Standard Maximum Wheel Speeds — SFPM

Wheel Type	Grit Size and Wheel Grade		
	36 and Finer		
	E & Softer	F, G	H & Harder
6 & 11	4500	5000	6000
2	5000	5500	6000
Other	5500	6000	6500

*Higher operating speeds must be noted on wheel orders. If approved an "E" will be added to the wheel grade to indicate "overspeed operation." Example: 2A60-H6-VRWE

VA Product Availability

Abrasive Types: 9A, 4A, 12A, 29A, 97A, 2A,
Abrasive Sizes: 24-220. See Table for Grade Availability
Wheel Thickness: 4 Structure - 24" Diameter Maximum
6 Structure - 10½" Maximum
8 Structure - 8" Maximum
10 Structure - 6" Maximum

Structure and Wheel Size	Grain Size								
	24	30	36, 46	54, 60	70, 80	90, 100	120	150	180, 220
4 Structure 1/4" Through 30" O D.			H-R	G-R	G-S	F-S	F-S	F-R	F-R
36" O.D.			H-R	G-R	G-S	F-R	F-Q	F-P	F-P
42" O.D.			H-R	G-R	G-S	F-Q	F-P	F-O	F-O
6 Structure Segments and Wheels 1/4" thru 42" O.D	H-N	G-N	G-N	F-N	F-N	F-M	F-M		
8 Structure Segments and Wheels 1/4" through 42" O.D.		F-M	F-M	E-M	E-M	E-L			
10 Structure Segments and Wheels 3" through 30" O.D.	E-K	D-K	D-K	D-K	D-K	D-K			

**Standard Maximum Wheel Speeds — Refer to VFM Speed Table

MIL 000034

VFM Product Availability

Abrasive Types: 9A, 4A, 12A, 29A, 97A, 2A, 32A
Abrasive Sizes: 24-220. See Table I for Grade Availability
Maximum Wheel Thickness: 4 Structure - 22" Maximum
6 Structure - 10½" Maximum
10 Structure - 6" Maximum

Structure and Wheel Size	Grain Size								
	24	30	36, 46	54, 60	70, 80	90, 100	120	150	180, 220
4 Structure 1/4" Through 30" O.D. 36" O.D. 42" O.D.			H-R H-R H-R	G-R G-R G-R	G-S G-S G-S	F-S F-R F-Q	F-S F-Q F-P	F-R F-P F-O	F-R F-P F-O
6 Structure Segments and Wheels 1/4" thru 42" O.D.	H-N	G-N	G-N	F-N	F-N	F-M	F-M		
10 Structure Segments and Wheels 3" through 30" O.D	E-K	D-K	D-K	D-K	D-K	D-K			

**Standard Maximum Wheel Speeds — SFPM

Wheel Type	Grit Size and Wheel Grade					
	46 and Coarser			54 and Finer		
	D	E	F & Harder	E & Softer	F	G & Harder
6 & 11	4500	5000	6000	4500	5000	6000
2	5000	5500	6000	5000	5500	6000
Other	5500	6000	6500	5500	6000	6500

**See special speed chart for overspeed applications

VSA Product Availability

Abrasive Types: MSB, 1MSB, 3MSB, 5MSB, 7MSB
Abrasive Sizes: 24-220. See Table for Grade Availability
Wheel Thickness: 8" Maximum

Structure and Wheel Size	Grain Size						
	24, 46	54, 60	80	100	120	150	180, 220
4 Structure 0 Through 30 O.D. Over 3" thru 42".	H-S H-S	G-S G-P	G-S G-P	F-Q F-O	F-Q F-O	F-Q F-O	F-N F-N
6 Structure 0 thru 3" O.D. Over 3" thru 42"	G-M G-M	F-N F-N	F-N F-N	F-M F-M	F-M F-M	F-M F-M	— —
8 Structure 0 thru 3" O.D. Over 3" thru 42"	E-L E-L	E-L E-L	E-L E-L	E-K E-K	E-K E-K	— E-K	— —
10 Structure Segments and Wheels Over 3" thru 30" O.D.	D-K	D-K	D-K	D-K	—	—	—

Wheel Grade	Minimum Wheel Thickness - Inches					
	1-8" O.D.	10"-14" O.D.	16"-20" O.D.	24" O.D.	30" O.D.	36"-42" O.D.
G & Softer	1/2	5/8	3/4	1	1-1/2	2
H & Harder	3/8	7/16	1/2	1/2	3/4	7/8

**Standard Maximum Wheel Speeds — Refer to VFM Speed Table

MIL 000035

VFP Product Availability (Engineered Grain Spacing)

Abrasive Types: 9A, 4A, 12A, 29A, 97A, 2A
Abrasive Sizes: 30-150 Grit. See Table
Wheel Thickness: 6" Maximum, 1/2" Minimum

Structure and Wheel Size	Grain Size				
	30, 36, 46	54, 60	70, 80	90, 100	120, 150
42 Structure 4" thru 30" O.D..	I-Q	H-Q	H-R	G-R	F-R
62 Structure 4" thru 30" O.D.	G-N	F-N	F-N	F-M	F-M
82 Structure 4" thru 30" O.D.	F-M	E-M	E-M	E-L	E-L

Standard Maximum Wheel Speeds — Refer to VFM Speed Chart

VFQ Product Availability (Engineered Grain Spacing)

Abrasive Types: 9A, 4A, 12A, 29A, 97A, 2A
Abrasive Sizes: 30-150
Wheel Thickness: 10" Maximum, 1/2" Minimum

Structure and Wheel Size	Grain Size				
	30, 36, 46	54, 60	70, 80	90, 100	120, 150
42 Structure 4" thru 42" O.D..	I-Q	H-Q	H-R	G-R	F-R
62 Structure 4" thru 42" O.D.	G-N	F-N	F-N	F-M	F-M
82 Structure 4" thru 42" O.D.	F-M	E-M	E-M	E-L	E-L

Standard Maximum Wheel Speeds — Refer to VFM Speed Chart

See page 1-23 for definition of Engineered Grain Spacing

Silicon Carbide Vitrified Wheels - VSC
VSC Product Availability

Abrasive Types: 5C, 6C, 7C
Abrasive Sizes: 24-220. See Table for Grade Availability
Wheel Thickness: Maximum, See Table

Structure and Wheel Size	Grain Size						
	*24, 30, 36	46	54, 60	70, 80, 90	100	120	150, 180, 220
4 Structure, 1/4 through 42" O.D.							
8" Maximum Thickness	P-Q	O-Q	O-Q	N-Q	M-P	M-O	M-N
6" Maximum Thickness	P-R	O-R	O-R	N-R	M-Q	M-P	M-O
4" Maximum Thickness	P-S	O-S	O-S	N-S	M-R	M-R	M-Q
2" Maximum Thickness	P-T	O-T	O-T	N-T	M-T	M-T	M-S
Sticks	P-U	O-U	O-U	N-U	M-U	M-U	M-T
6 Structure, 1/4 Through 42 O.D.							
8" Maximum Thickness	G-Q	F-Q	F-Q	E-Q	E-P	E-O	E-N
6" Maximum Thickness	G-R	F-R	F-R	E-R	E-Q	E-P	E-O
4" Maximum Thickness	G-S	F-S	F-S	E-S	E-R	E-R	E-Q
2" Maximum Thickness	G-T	F-T	F-T	E-T	E-T	E-T	E-S
Sticks	G-U	F-U	F-U	E-U	E-U	E-U	E-T
10 Structure Segments and Wheels 3" through 30" O.D. 8" Maximum Thickness	F-N	F-M	D-L	D-L	D-L	D-L	

*3¼" and smaller O.D. wheels are not available in 24, 30 or 36 grit.

NOTE: Wheels larger than 16" thru 20" thick will be made in 3 equal sections. Example: a 20" thick wheel will be made in 3-6.667" sections. Thickness tolerance for each section will be +.020, -.000.

VSC - Silicon Carbide

*Standard Maximum Operating Speeds — SFPM

Wheel Type	Grit Size and Wheel Grade		
	24 Grit and Finer		
	G	H	I & Harder
6 & 11	4500	5000	6000
2	5000	5500	6000
Other	5500	6000	6500

*Higher wheel speeds must be noted on wheel orders. An "E" will be added to the wheel grade to indicate "overspeed operation." Example: 6C60-H6-VSCE

Available Grades for Operating Speeds up to and including 8500 SFPM

1. All 4 structure VSC wheels.
2. 6 structure VSC wheels listed below.

NOTE: I.D. must not exceed 60% of O.D.

Grit Size	Bond	Available Grades
24-36	VSC	K6-U6
46	VSC	H6-U6
54-60	VSC	G6-U6
70-90	VSC	E6-U6
100-120	VSC	E6-U6
150-180	VSC	E6-T6
220	VSC	E6-T6

MIL 000037

Resinoid Wheels
B90 Bond - General Purpose

Availability

Abrasive Types: Aluminum Oxide - 9A, 4A, 12A, 29A, 97A, 2A
Silicon Carbide - 5C, 6C, 7C
Mixtures of Aluminum Oxide & Silicon Carbide - C9A, C4A, C12A, C2A

Abrasive Sizes: 24-220 Grit. 5C Available in 36-220 Grit Only

Wheel Thickness: 14" Maximum Dependent on Available Tooling

Grit Size	Wheel Size 42" O.D. And Smaller			
	6 Structure	9, 11 Structure	13 Structure	15 Structure
24	—	E-R	—	—
30	—	D-R	E-R	E-R
36-80	K-T	D-R	E-R	E-R
90-100	K-T	D-R	E-R	—
120	—	D-R	E-R	—
150-220	—	D-R	—	—
Segments	—	D-R	—	—

*Standard Maximum Wheel Speeds — SFPM

Wheel Type	Grit Size and Wheel Grade					
	24 Grit and Finer			36 Grit and Finer		
	F and Softer	G-L	M and Harder	F and Softer	G-K	L and Harder
IN, IP	5000	7000	8500	5000	7000	8500
2, 2N, 2P	5000	6000	7000	5000	6000	7000
6, 11	5500	7500	8500	5500	7500	8500
Others	6000	8000	9500	6000	8000	9500

*Higher wheel speeds must be noted on wheel orders. If approved an "E" will be added to the wheel grade to indicate "overspeed operation." Example: 2A60-L9-B90E

Metric Conversion of Some Standard Size Grinding Wheels

Size	Metric	Size	Metric
6" x 1/2" x 1 1/4"	152.4 x 12.7 x 31.75	20" x 3" x 12"	508 x 76.2 x 304.8
7 x 1/4" x 1 1/4"	177.8 x 6.35 x 31.75	20" x 4" x 12"	508 x 101.6 x 304.8
7 x 1/2" x 1 1/4"	177.8 x 12.7 x 31.75	20" x 6" x 12"	508 x 152.4 x 304.8
7 x 3/4" x 1 1/4"	177.8 x 19.05 x 31.75	24" x 1" x 12"	609.6 x 25.4 x 304.8
8" x 1/4" x 1 1/4"	203.2 x 6.35 x 31.75	24" x 2" x 12"	609.6 x 50.8 x 304.8
8" x 1/4" x 1 1/4"	203.2 x 6.35 x 31.75	24" x 4" x 12"	609.6 x 101.6 x 304.8
8" x 1/2" x 1 1/4"	203.2 x 12.7 x 31.75	24" x 6" x 12"	609.6 x 152.4 x 304.8
8" x 3/4" x 1 1/4"	203.2 x 19.05 x 31.75	24" x 8" x 12"	609.6 x 203.2 x 304.8
10" x 1" x 3"	254 x 25.4 x 76.2	24" x 10" x 12"	609.6 x 254 x 304.8
12" x 3/4" x 3"	304.8 x 19.05 x 76.2	30" x 1" x 12"	762 x 25.4 x 304.8
12" x 1" x 3"	304.8 x 25.4 x 76.2	30" x 2" x 12"	762 x 50.8 x 304.8
12" x 3/4" x 5"	304.8 x 19.05 x 127	30" x 3" x 12"	762 x 76.2 x 304.8
12" x 1" x 5"	304.8 x 25.4 x 127	36" x 1" x 12"	914.4 x 25.4 x 304.8
14" x 1" x 5"	355.6 x 25.4 x 127	36" x 2" x 12"	914.4 x 50.8 x 304.8
14" x 1 1/2" x 5"	355.6 x 38.1 x 127	36" x 3" x 12"	914.4 x 76.2 x 304.8
16" x 2" x 5"	406.4 x 50.8 x 127	42" x 1" x 12"	1066.8 x 25.4 x 304.8
18" x 3/8" x 9"	457.2 x 9.53 x 228.6	42" x 1 1/2" x 12"	1066.8 x 38.1 x 304.8
20" x 1" x 12"	508 x 25.4 x 304.8	42" x 2" x 12"	1066.8 x 50.8 x 304.8
20" x 2" x 12"	508 x 50.8 x 304.8		

For other metric size availability call Cincinnati Milacron Customer Service 1-513-841-8721.

MIL 000038

Grade Limits — B90 Excalibur

	Wheel Size						
	30" & Smaller		36"		42"		Segments
Structure	9	7	9	7	9	7	9
Grain Size							
24	E-R	S-Z	E-R	S-Z			E-P
30-54	D-R		D-R		D-R	S	E-P
60						S-Z	E-P
70						S-X	E-P
80				S-Y		S-Y	E-P
90-100				S-W		S-U	E-P
120				S-V			
150-180		S-Y		S-U			
220		S-X		S-U			

Use 6 or 9 structure for B90 Bond
When converting from Vitrified to Resin Bonded wheels, go 5 grades harder, i.e. 29A801-K6-VFM to 29A801-P6-B90.

Grade And Grit Size Limits For Multigrade Wheels

Underlined grades and grit sizes indicate the maximum spread permitted for multigrade wheels.

*Grit Sizes					*Grades				
36	46	54	60	70	H	I	J	K	L
46	54	60	70	80	I	J	K	L	M
54	69	70	80	90	J	K	L	M	N
60	70	80	90	100	K	L	M	N	O
70	80	90	100	120	L	M	N	O	P
80	90	100	120	150	M	N	O	P	Q
90	100	120	150	180	N	O	P	Q	R
100	120	150	180	220	O	P	Q	R	S

*Availability also governed by grade and grit size restrictions in vitrified and resin sections.

NOTE: Structure number must be the same for all portions of the wheel. For example, 97A1201-L4-VFM hardside is not available on a 97A801-J6-VFM wheel.

NOTE: If grades are the same and only the grit size is varied, the finer side is considered to be the hard side.

NOTE: It is very difficult to differentiate between the hard and soft sides in the finished product for identification purposes. A small vitrified wheel (ceramic button) is placed in the soft side of multigrade wheel at molding near the wheel I.D. This button will be white (9A) in blue wheels (2A) and blue (2A) in white wheels (9A).

Variable Density Wheels

Variable density wheels are made so that the density varies from the periphery toward the center.

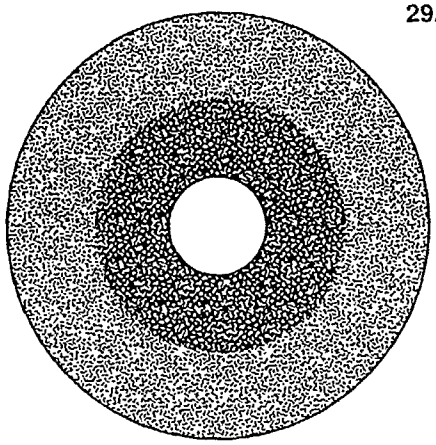
	Wheel Type	
	Centerless et al	Discs
Described as	Variable Density	Zoned
Denser Harder Portion at	ID	OD
Hardness is Specified by Multiple	Structure Numbers	Grade Letters
Typical Specifications	6C36-K9/5-B2 2A60-M6/4-VFM	*2A46-H/G/F13-B2
Wheel, OD, Minimum	20"	12"

*No change can be made in grain type or size

Type 1 wheel sizes available with the provision that maximum thickness limit must be used in conjunction with the available tooling.

Wheel Size		Maximum	Minimum
OD	ID	Thickness (Nominal)	Thickness
0	12	6	1
24	12	10	1
30	12	10	2
36	12 to 20	10	2
42	12 to 20	10	2

Variable Density Type 1 Wheel

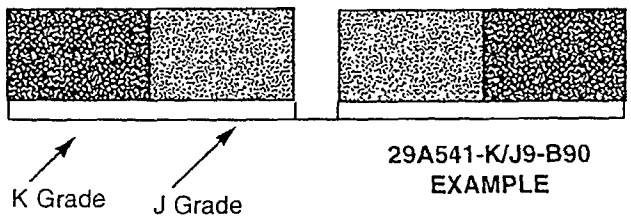


29A601-K6/4-VFM EXAMPLE

Outer Diameter 6 Structure

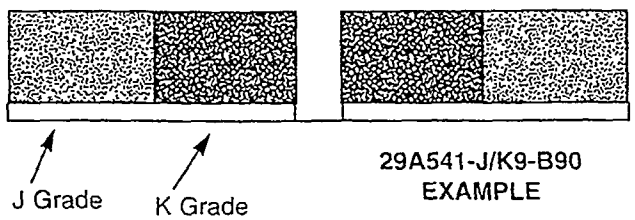
Inner Diameter 4 Structure

Disc Wheel



29A541-K/J9-B90 EXAMPLE

Disc Wheel



29A541-J/K9-B90 EXAMPLE

Standard Treatments For Vitrified Bonded Products

"B" Treatment - Sulfur Impregnation
"D" Treatment - Wax Impregnation
"D2" Treatment - Special Impregnation
"R" Treatment - Resin Impregnation For Mounted Points
"S" - Wax Impregnation For Mounted Points

Treatment	Availability
"B"	Segments, Wheels, and Mounted Points ≤18" O.D., ≤3" Thick Wheels Not Available in VRW, VQC or VSA
"D"	Wheels ≤6" O.C., ≤4" Thick Wheels >6" O.D., ≤2" Thick Wheels Not Available in VRW, VQC or VSA
"D2"	Wheels ≤30" O.D., ≤3" Thick Wheels 46 & Finer, 4 & 6 Structure
"R" & "S"	Mounted Points

Note: Treatments not available for plate mounted or nut inserted disc wheels.

MIL 000040

Your Future Grinding

When you buy CIMFORM® grinding wheels you're assured of new and improved products. Cincinnati Milacron has many new product development research laboratories, plus numerous other testing and customer service laboratories, and over 10% of company employees work in research, development and engineering.

First there's *basic research.* We investigate basics like wheel hardness as a performance characteristic in terms of resistance to wear, tendency to cause metallurgical damage and tendency to create high power demand. One basic research project was a comparison of theoretical predictions of the effects of wheel speed with laboratory results on commercial parts ground at speeds of 12,000 sfpm to 20,000 sfpm.

In our Abrasive Development Laboratory, engineers and technicians develop new bonding systems and products for grinding applications. VQC was developed to meet the need for increased part quality without increased costs. The Abrasive Development Laboratory also develops new processes to manufacture grinding wheels more efficiently. Here, in addition to developing new products, we check all incoming materials for quality, constantly run value analysis checks in competitive products, and work to improve existing products.

The complex structure of grinding wheels requires scientific knowledge in areas of organic and inorganic chemistry, and ceramics. Cincinnati Milacron's research into the grinding wheel field has brought wheels with improved bonding materials, and entirely new additives to aid the grinding process.

The development of our CIMFORM® line of wheels is a prime example. CIMFORM® Grinding Wheels were developed to offer superior solutions to a wide range of challenging grinding and metalworking applications. CIMFORM® products include Vitrified Bonded Abrasives, Resin Bonded Abrasives, Diamond/CBN Superabrasives and a range of Accessories and Supportive Services. For additional information on the full line of CIMFORM® products, see accompanying chart.

In our Products Testing laboratory we test new and improved product developed by our Abrasive Development Laboratory in actual use in machines. Technicians with machine tool backgrounds use the latest scientific equipment to evaluate grinding wheels on performance factors like wheel life, number of pieces per dress, cubic inches of metal removed per cubic inch of wheel wear (grinding ratio), rate of stock removal, power consumed, finish, pounds of metal removed per hour and pressure required.

This work is done in close coordination with our CIMCOOL® Metalworking Fluid division and with other divisions of Cincinnati Milacron. We test new machines to find the best machine-wheel-fluid combination.

The work of the Products Testing Laboratory in the practical application of wheels is not the last stop in testing abrasive products in use. CIMFORM® Grinding Wheels are also tested in many Cincinnati Milacron plants. These plants are among our toughest customers. We then field test on selected customer applications before actual market release. One thing is certain — you never get a CIMFORM® Grinding Wheel until it is thoroughly production proved.

The Consumable Products Division of Cincinnati Milacron makes all the popular sizes, shapes and gradings of precision grinding wheels. Aluminum oxide, silicon carbide, diamond, cubic boron nitride or mixed grain abrasive wheels are supplied with vitrified, resin, rubber and various other bonds.

CIMFORM® Grinding Wheels are made from 1/4" to 42" in diameter, and from 1/32" to 21" in thickness. Internal wheels of 1/4" diameter grind the inside diameter of miniature bearing races. Wheels of 42" diameter grind bearing surfaces on automotive crankshafts. Wheels have been made, in sections, of 5' and more in diameter (for lapping transmission parts) and 6' wide (for grinding limestone slabs.) Our wheels range from tiny points the size of a dentist's drill to wheels weighing more than 1/4 ton.

CIMFORM® Grinding Wheels have contributed to the higher speeds required of the new grinding machines. We now manufacture wheels to operate at 16,000 sfpm. Wheels for even higher speeds are in the offing.

- Precision centertype wheels
- Precision centerless wheels
- Centerless regulating wheels
- Surface grinding wheels
- Creep-Feed grinding wheels
- Cylinder wheels
- Segments
- Internal grinding wheels
- Cutter grinding wheels
- Diamond wheels
- Cubic boron nitride wheels
- Roll grinding wheels
- Disc (plate mounted) wheels
- Nut-inserted wheels
- Cutoff wheels
- Mounted wheels
- Valve Seat grinding wheels

A complete line of foundry snagging, resin, non-precision and off hand (portable) grinding wheels

Product Line (cont.)

CIMFORM® Brands

Vitrified Bonded Abrasives
- Super®
- CMSA®
- CMSA II®
- Fintech®

Resin Bonded Abrasives
- Precision
- Excalibur®
- Snagging/Portable/Cut-Off (SPC)
- Apex 2000®
- Crusader®
- SuperLancer®

Diamond/CBN Superabrasives
- Marathon®
- Marathon 2®
- VIDA®
- Toolmaster®

Accessories and Supportive Services
- Abrasive Engineering
- CIMFORM Predict-A-Grind 130®
- Neverdull®
- GSE
- Training

CIMFORM Predict-A-Grind 130®

This innovative software is yet another part of the unique program offered by Cincinnati Milacron's "Grinding Systems Engineering" (GSE) Team. This Team has been using an analytical approach to improving their customers' grinding processes since the department was founded in 1988.

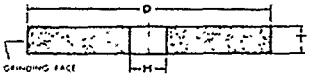
Ease-of-use and range of applications are additional substantial advantages of CIMFORM® PREDICT-A-GRIND 130™. Virtually anyone involved in grinding can use the software's numerous features, with significant return for process improvements. CIMFORM® PREDICT-A-GRIND 130™ can be used in both DOS and Windows versions.

Unique features of CIMFORM® PREDICT-A-GRIND 130™ include:

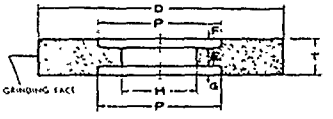
- Allows metric/inch input of information (or combination of both)
- Recommendations based on actual grinding process data
- Provides data necessary to make grinding cycle and process improvements
- Defines process limitations and lists constraints for machine, part and measurements
- Determines production rates
- Allows for cycle design for various abrasives and bonding
- Instantaneous response of calculations
- User friendly prompting for 25-35 necessary items of input data
- Listing of important output data; machine set-up parameters and settings
- Identifies force levels, both normal and tangential
- Additional programs for machine static stiffness test and calculations
- Defines optimum wheel speed and wheel width
- Features "Help Key" for immediate on-line assistance
- Software provides all the outputs required for grinding process improvements and has been tested under production conditions

Contact your Cincinnati Milacron Representative to learn more about these and other programs Milacron has to offer.

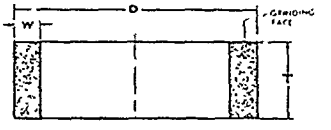
TYPE 1 STRAIGHT WHEELS



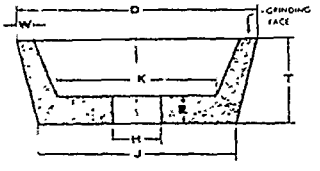
TYPE 7 DOUBLE RECESSED WHEELS



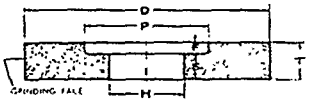
TYPE 2 CYLINDER WHEELS



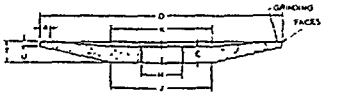
TYPE 11 FLARING CUP WHEELS



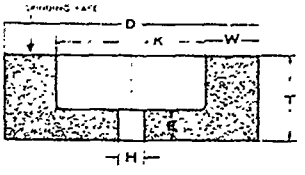
TYPE 5 RECESSED ONE SIDE WHEELS



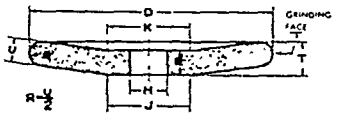
TYPE 12 DISH WHEELS



TYPE 6 STRAIGHT CUP WHEELS



TYPE 13 SAUCER WHEELS



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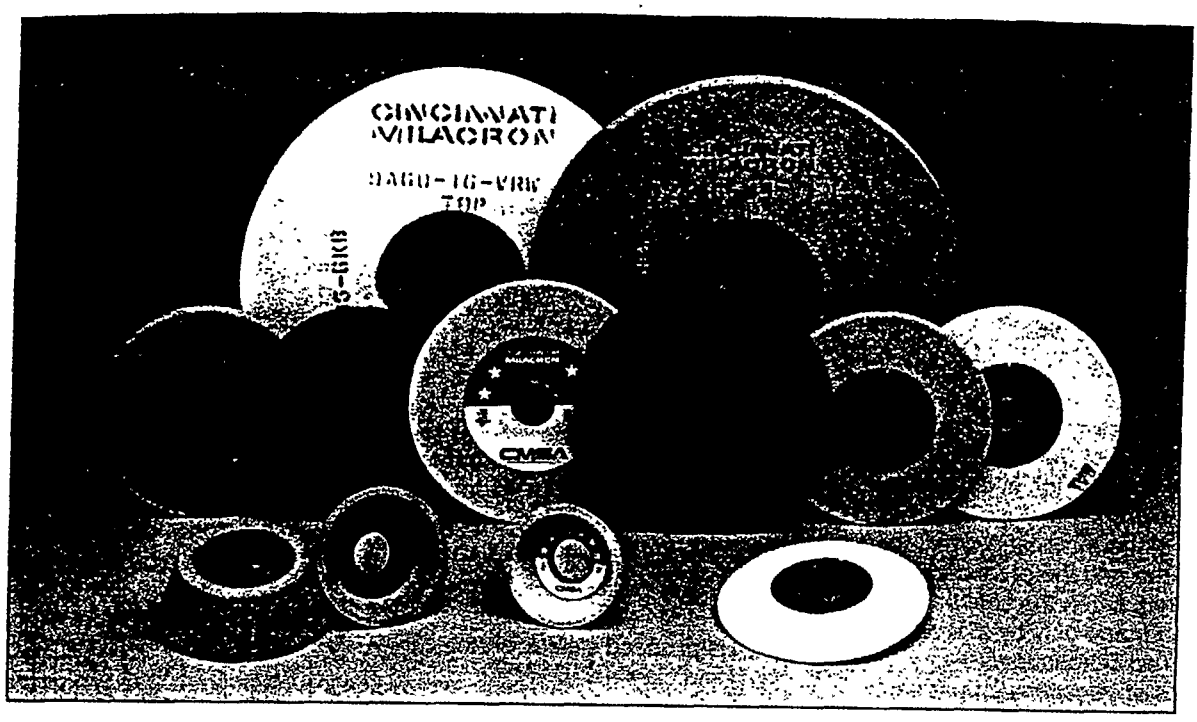
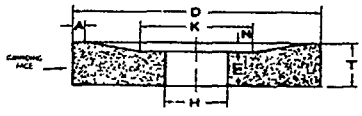
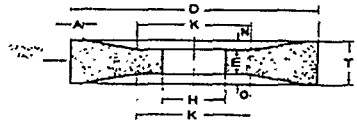


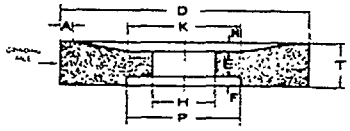
Type 20 — Relieved One Side



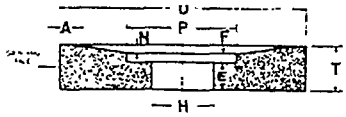
Type 21 — Relieved Two Sides



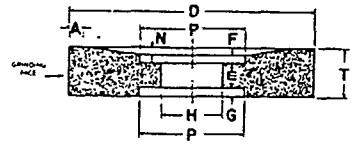
Type 22 — Relieved One Side, Recessed Other Side



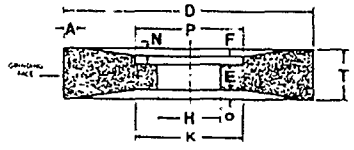
Type 23 — Relieved and Recessed Same Side



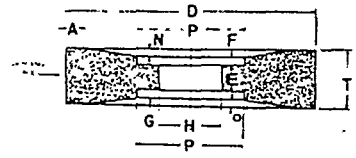
Type 24 — Relieved and Recessed One Side, Recessed Other Side



Type 25 — Relieved and Recessed One Side, Relieved Other Side



Type 26 — Relieved and Recessed Both Sides



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Meaning Of Markings

Wheel Grade

Factors to consider when grading a wheel for a particular application are abrasive type, grit size, hardness, structure and bond type.

Abrasive type

Grinding wheels are made with one of the basic abrasives or a mixture of them. Selection of the correct abrasive for a particular job is dependent on such factors as the type and hardness of the material ground, the finish desired and the production rate required. Often the final selection can be made only by trial on the job. (*See Two Components — Thousands of Variations* on page 6 for more details on abrasives.)

Usually one of the following basic abrasives will meet the needs of the job.

Basic Abrasives

A — Tough, brown aluminum oxide — usually for rough grinding applications

2A — Blue or brown aluminum oxide — general purpose, most frequently recommended

4A — Off white aluminum oxide — production & tool grinding

9A — White aluminum oxide — tool grinding

12A — Pink aluminum oxide — production and tool grinding; particularly suited to hard, heat sensitive materials

13A — Another pink semi-friable abrasive suited for grinding chrome or materials high in chrome.

W5A — Steel foundries snagging

15A — Same only more durable

18A — Same only slightly softer

W5C — Cast iron foundry snagging

15C — Same only more durable

18C — Same only slightly softer

AZ — Foundry (Steel and Cast Iron) portable snagging

5C — (green), 6C (black) — Silicon carbide — general purpose; rough grinding tungsten carbide

MD — Diamond — wet and dry grinding (mostly carbide)

AMD — Copper coated diamond — dry grinding (carbide)

CMD — Nickel coated diamond — wet grinding (mostly carbide)

EMD — Nickel coated friable diamond — wet grinding (carbide)

DMD — Blocky diamond for grinding combinations of steel & carbide

1BN — Nickel coated cubic boron nitride — grinding hardened high speed steel, tool steel and die steel

2BN — Uncoated cubic boron nitride for production grinding operations

Resin Bond System

CA — Mixed aluminum oxide and silicon carbide — 6C and A

C2A — Mixed aluminum oxide and silicon carbide — 6C and 2A

C4A — Mixed aluminum oxide and silicon carbide — 6C and 4A

C9A — Mixed aluminum oxide and silicon carbide — 6C and 9A

C12A — Mixed aluminum oxide and silicon carbide 6C and 12A

Mixed Abrasives

On some applications mixtures of abrasives are preferred.

Vitrified and resin bond system

97A — Mixed 2A and 9A aluminum oxide (gray)

29A — A higher friability mixture of 2A-9A (light gray)

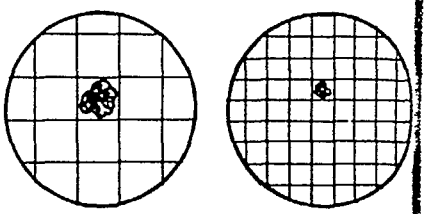
7C — Mixed silicon carbide 6C and 5C

Abrasive grain size

The size of individual abrasive grits influences the stock removal rate, chip clearance in the wheel, and corner holding ability.

Abrasive grain size is determined by the size of the screen through which the grits will pass. The number of the nominal size indicates the size of the opening in the screen. A low number of grain size indicates a large grain, and a high number denotes a fine grain. Although the problem of screening grain sizes is complicated because of the unsymmetrical shapes of the grits, some idea of the grain sizes in inches can be gained by knowing the size of the square opening between the wires through which the grain will not quite pass:

30 grit	.0232" square hole
60 grit	.0098" square hole
120 grit	.0035" square hole



The grit size number may also indicate a combination of two or more adjacent sizes. Combinations are often found to provide a more efficient grinding action than single sizes.

Grain size varies from 8 (very coarse) to 800 (very fine). Choice of grain size for a given operation depends on stock removal rate, surface finish desired and workpiece material.

The coarsest grit sizes (8 through 20) are used for billet conditioning and snagging, where the purpose is to rapidly remove large amounts of excess or impure material with little concern about surface roughness or geometry of the part.

Ceramic Grains

1MSB	1WB	10% Ceramic
3MSB	3WB	30% Ceramic
	4WB	40% Ceramic
5MSB	WB -6WB	50% Ceramic
MSB	BG	100% Ceramic
DA (usually resin)		25% Ceramic

MIL 000044

Sizes 24 through 46 are also normally used in high stock removal operations where geometry is important and some control of surface finish is required on soft materials.

Finish depends upon several wheel characteristics. Fine surface finishes may often be attained with the use of a fine grain wheel. However, surface finish is also dependent upon the glaze of the wheel (flatness of the grain) so that a properly dressed coarse grain wheel may also yield fine surface finishes. Other variables in producing fine surface finishes are bond type, wheel hardness and stock removal rate.

Finer grit sizes do help significantly in grinding hardened work. Here there is less tendency for the wheel to load (metal in the wheel face) than in grinding softer work; and the fine grain has better penetrating ability on the hard workpiece. On stock removal operations fine grain generates more heat, so steps should be taken to quench the additional heat.

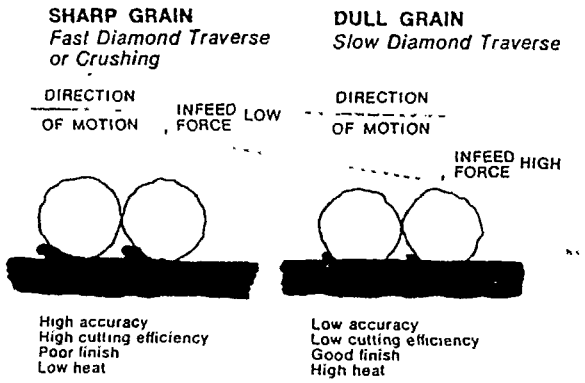
On softer materials, where the tendency to load is greater (large ductile chips), the coarser grain sizes are more efficient (more pieces per dress or higher metal removal rate) because of the greater chip clearance between the grains.

Wheel hardness

The grade of a grinding wheel is a measure of the strength of the bonding holding the individual grains in the wheel — the major factor being the average diameter of the individual bond posts. Grade letters range from A to Z in the order of increasing bond content (Marking Chart page 36, Section 1).

If the bond post is not strong enough to withstand the forces imposed on it, fracture occurs and grain is discharged from the wheel. The wheel is then said to be "soft acting."

If this does not take place at a too-rapid rate, it becomes an ideal condition for rough grinding. However, precise control of this breakdown is quite difficult and rarely is accomplished in industry. A greater degree of control may be had for roughing by using a wheel having a somewhat larger-diameter bond post (higher-in-the-alphabet grade letter) and free



running mechanical roll dresser such as a Desmond.

When surface finish is important the bond post diameter must be large enough (grade letter high enough in the alphabet) to prevent the grain from being lost from the wheel face during grinding. The wheel is now said to be "hard acting". The wheel is dressed slowly with a diamond; the flat surfaces left on the grain will develop a good surface finish. See Wheel Dressing, page 24 for more information on dressing. Figure above shows conditions associated with grain condition (sharp grain — dull grain).

A grinding wheel consists of only two ingredients: the abrasive grain and the bonding material that holds the grains. But it is far from being a simple product. With differences in type of grain and bond, and their proportions, about one-quarter of a million different standard size, shape and grading variations are possible.

Except for diamond, manufactured abrasives have almost completely replaced natural abrasives such as emery and the quartzite used in sandpaper. Even with diamond, the manufactured abrasive has increasingly supplanted the natural product.

The three prime characteristics of abrasives that govern grinding performance are hardness, toughness and reactivity with work materials.

Because of the complexity of the grinding process, including the nature of abrasive wear, guidelines for selecting abrasive type are based on accumulated experience.

Aluminum oxide

Aluminum oxide is made by refining bauxite ores in an electric furnace. The bauxite is first heated to drive off moisture, and then mixed with coke and iron borings to form the furnace charge. After the mixture has been fused and cooled, the resulting rock-like mass is crushed and screened into the various grain sizes.

The color and the toughness of the abrasive is determined by the amount of impurities (iron oxide, titanium oxide and silica). toughness is also strongly affected by additives.

Aluminum oxide, the most popular abrasive by a wide margin, is usually recommended for grinding most steels, annealed malleable and ductile iron, and nonferrous cast alloys.

Specialized aluminas include fused mixtures of zirconium oxide and aluminum oxide for high production snagging, and sintered alumina, which is extremely tough, for billet conditioning and other very high stock removal snagging.

Aluminum oxide — chromium oxide alloy is used to combine the cool, low stress grinding action of high purity aluminum with low abrasive wear. The result is Cincinnati's famous pink grinding abrasive, which is particularly well suited for abrasive resistant, heat sensitive tool steels.

Silicon carbide

Silicon carbide (SiC) is made by mixing pure white quartz (sand) and fine petroleum coke, plus some salt and sawdust, in an electric furnace. This process is one of synthesizing or combining the sand and coke, in contrast to refining bauxite into aluminum oxide. Again the resulting crystalline mass is crushed and graded by particle size.

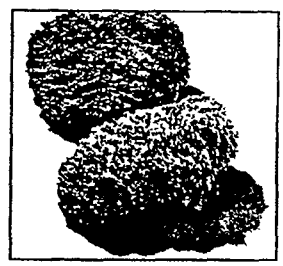
Silicon carbide is sometimes used for grinding gray iron and unannealed malleable iron, nonferrous metals like copper, brass, aluminum and magnesium, and nonmetallics, including gem stones.

MSB (Ceramic)

MSB is a non-seeded ceramic aluminum oxide abrasive that is an extremely tough and durable abrasive in all grades. This grain is chemically quite pure and of uniform quality. It is comprised of a complex poly crystalline microstructure. When used in a grinding wheel it is blended, in varied percentages, with a more friable conventional aluminum oxide.

A grinding wheel such as this has a much longer and more productive life. The MSB abrasive stays much sharper longer and breaks down in smaller increments.

The act of redressing the wheel is accomplished in smaller increments for it is no longer necessary to knock out entire grains, or parts of grains simply retouch the face of the MSB wheel .0005 to .0010" deep (In many cases a new diamond dressing tool needs to be installed, especially if the present one is dull or flat.).



Diamond

Diamond is the hardest known substance. Until recently use of diamond abrasive was generally limited to hard and dense materials like cemented carbides, marble granite, glass and other ceramics. However recent developments in manufactured diamonds leading to controlled crystal configurations and surface coatings have expanded its use in the grinding of other metals in some specialized cases.

Cubic boron nitride

This newest manufactured abrasive has a hardness second only to diamond and is 2.5 times as hard as aluminum oxide. It can withstand temperature of 2500F, whereas diamond begins to burn around 1300. In its metal-coated form, cubic boron nitride has proved generally superior to both manufactured diamond and aluminum oxide in grinding superhard high speed steel, tool steel and die steel. It does not, however, compete with diamond in grinding tungsten carbide

The abrasive grains are the cutting tools of a grinding wheel. They are held in position by one of several bonds. The three major bond types are organic, ceramic or vitrified, and metal.

CBN Grain

Vitrified bonds

Ceramic or vitrified bonds are strong, rigid and retain high strength at elevated temperatures, but their lower shock resistance inhibits their application where mechanical impact or large temperature differentials are likely to occur. Power demand, grinding pressure, workpiece temperature and geometry variation are nearly always lower with vitrified wheels. Vitrified bonds are also practically unaffected by exposure to water- and oil-based grinding fluids.

Vitrify means to change into glass by heat and fusion. A vitrified bond is glass-like. Various ceramic materials, such as clay, feldspar, or frit, are mixed with the abrasive grains and heated slowly and carefully to around 2300F. At this temperature the ceramic materials are fused, or melted, and when cooled they form a glass-like, porous structure in which the abrasive grains are held.

Organic bonds

The organic bonds (resin, rubber and shellac) have better mechanical and thermal shock resistance than other bonds. It is also the predominant choice for diamond when used in metalworking. Rubber-resin bond is used for centerless grinder regulating wheels and for cutoff wheels where the piece being cut must be cut to close limits and where the finish of a cut is important.

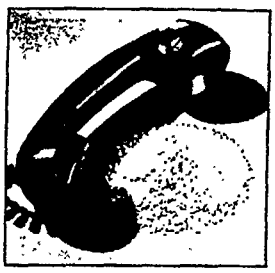
The amount of heat generated in some high stock removal operations even with grinding fluid creates large temperature differences in the grinding wheel. Therefore organic bonds are required to withstand the thermal stresses. Organic bonds being more resilient or yielding tend to generate smoother surface finishes and to tolerate more variation in machine

setups. However the resiliency also tends to cause higher power demand, more heat generation with possible workpiece burn and poorer geometry control. Resin bonds are likely to be softened by prolonged exposure to water based grinding fluids.

Powdered phenol formaldehyde resin and abrasive grains are mixed together to form resin wheels. At the relatively low temperature of 350F the plastic resin flows around the abrasive grains and undergoes an irreversible chemical change. When cooled, the resulting wheel is less brittle and more resistant to thermal stress than a vitrified wheel.

Metal bonds

Compared to vitrified and organic bonds, the uses of metal bonds are limited.



The major use of metal bonds is with diamond abrasive for grinding under harsh conditions. The metal bond diamond wheel removes material slowly and frequently with high heat generation, but in many applications such as certain glass grinding, abrasive wheel shaping, and concrete or stone sawing, the long life outweighs these disadvantages.

Metal bonds are also used with aluminum oxide or diamond abrasive to provide conductive wheels for electrolytic grinding.

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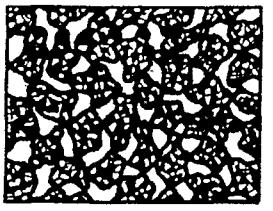
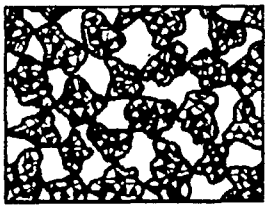




Wheel structure

The structure number in the wheel grading following the grade letter is in reality a number indicating a density chart (in a 0 to 15 range a low structure number indicates a close compaction, a high one less compaction). Generally a change in structure has little effect on grinding.

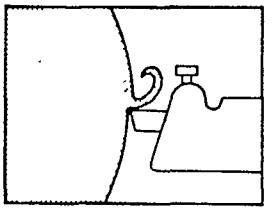
In some coarse grain surface grinding wheels it is desirable that the wheel have more porosity than normal. this is done by using a granular material as part of the abrasive mix. After molding, this granular material will leave the mix as a gas before or during firing. The additional voids left in the mix through the use of the granular material are known as induced porosity and may be designated by a high structure number, an additional bond symbol, or both.

Concentration in diamond and cubic boron nitride wheels is akin to structure in other abrasive wheels in that it is a measure of abrasive per unit volume of grinding wheel. However, the total stock that can be removed with a diamond or cubic boron nitride wheel is usually directly proportional to the amount of diamond or cubic boron nitride it contains. Therefore, concentration is a much more important characteristic in diamond and cubic boron nitride wheels than is structure in other abrasive wheels.

As with structure and grade, there is no published standard that established quantitative values to designations. However, most diamond wheel producers have adopted the convention in which 100 concentration designates 72 carats of diamond per cubic inch of wheel and smaller concentration numbers refer to the fractional part of 100 concentration in the wheel; that is, 50 concentration designates 36 carats per cubic inch. The cubic boron nitride wheel convention is similar but, rather than 100 concentration designating 72 carats, 100 concentration designates 25 volume percent of the rim structure. The difference is academic as far as the density is concerned 100 concentration in a cubic boron nitride wheel designates exactly the same volume of abrasive as 100 concentration in a diamond wheel.

Bond

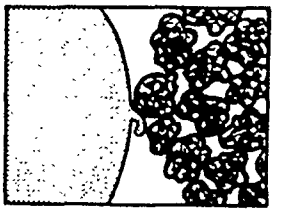
Just as a lathe has a tool post to hold the bit, so a grinding wheel has a bond to hold the grits in cutting position. the bond itself does not remove metal; its main function is to hold the grains in the cut with varying degrees of strength (grade).



The first bond symbol, such as V, denotes the general type of bond (vitrified, resin, etc.) and is the same for all manufacturers. The second symbol, consisting of one or more letters or digits, such as S, is the manufacturer's code for a particular modification of the bond, and also for such features as induced porosity, special treatment or reinforced wheels. This second symbol is optional.

Engineered Grain Spacing

For some applications it may be necessary to use an induced porosity we call engineered grain spacing.



Engineered grain spacing is a concept of optimized bonding of abrasive grains where the optimum strength of bonding is obtained with minimum of bond content. The higher porosity of the grinding wheel is engineered to be distributed in such a way that the optimum strength of the bonding system is achieved with out addition of bonding material.

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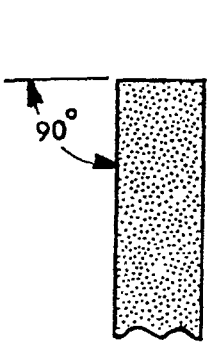
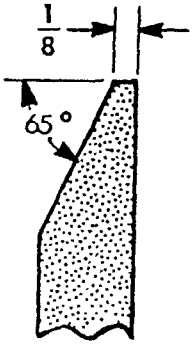
Standard Shapes of Grinding Wheel Faces



A



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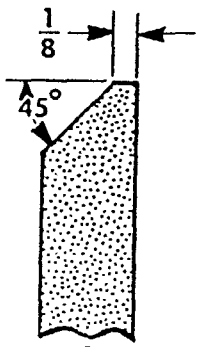
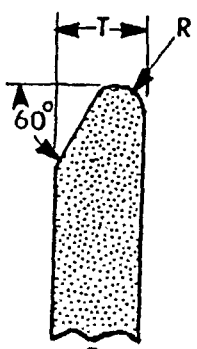
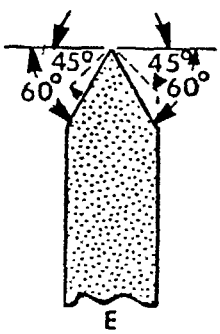


C

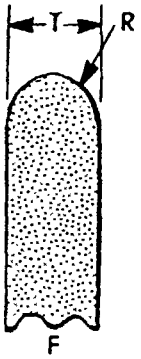


D

$R = \frac{3T}{10}$

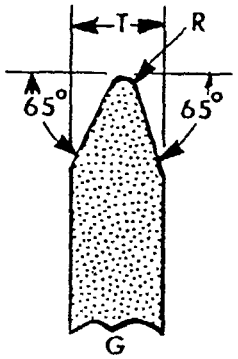


E



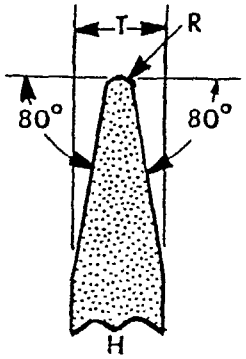
F

$R = \frac{T}{2}$



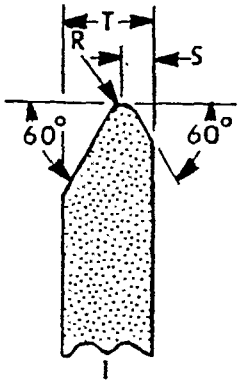
G

$R = \frac{T}{8}$



H

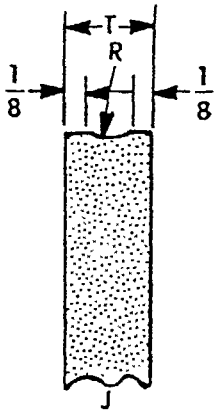
$R = \frac{T}{8}$



I

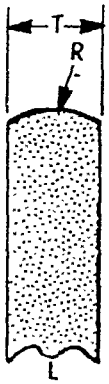
$R = \frac{T}{8}$

$S = \frac{T}{3}$



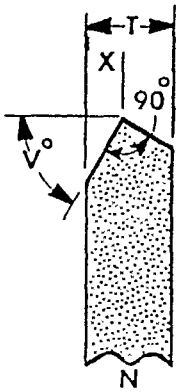
J

$R = \frac{7T}{10}$



L

R = T

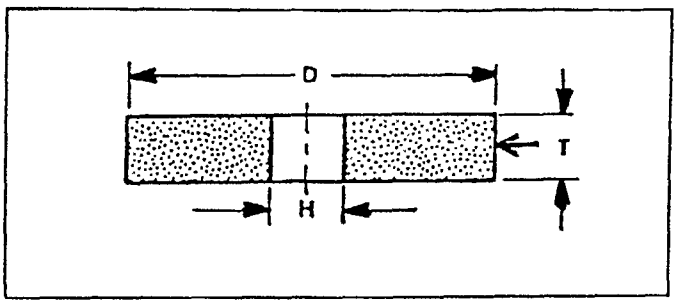


N

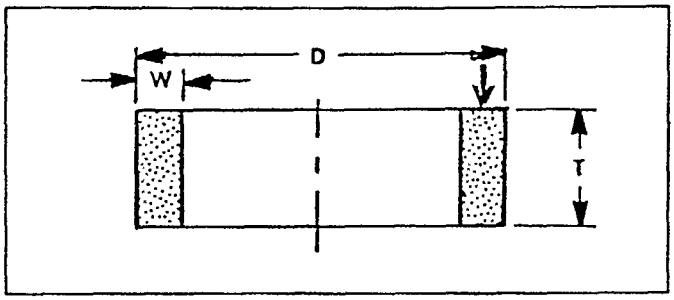
"X" is the narrower wheel face
30° Angular Grinder, V=60°
45° Angular Grinder, V=45°

For face N, dimensions V, X, and T are specified by the user.

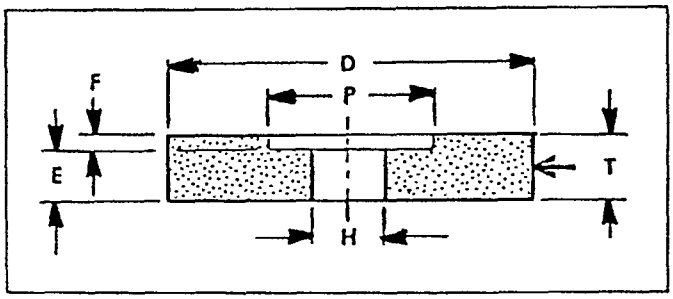
MIL 000049



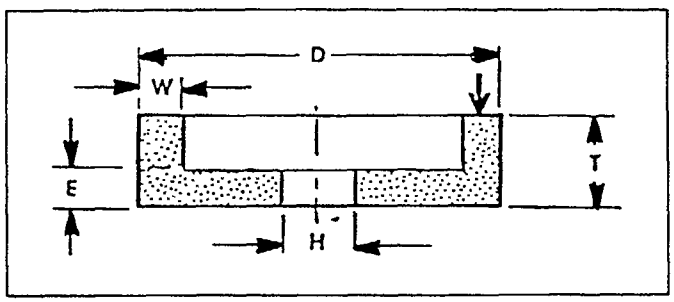
Type 1 - Straight wheel.
Peripheral grinding wheel having a diameter, thickness and hole.



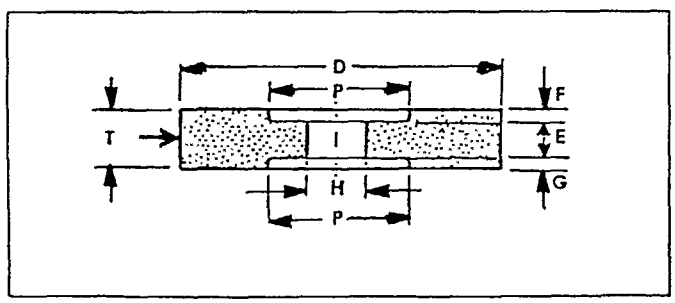
Type 2 - Cylinder wheel.
Side grinding wheel having a diameter, thickness and wall wheel is mounted on the diameter, or a similar wheel mounted in a chuck or on a plate.



*Type 5 - Wheel, recessed one side.
Peripheral grinding wheel having one side straight or flat and the opposite side recessed. A recessed wheel allows wider faced grinding wheel to be used when the available mounting thickness (E) is less than the required overall thickness (T). The recess allows grinding clearance for the nut and flange.



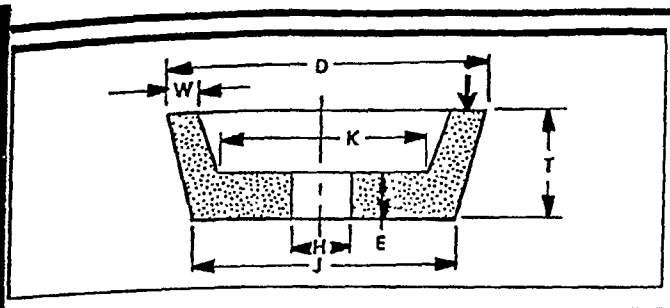
*Type 6 - Straight-cup wheel.
Side grinding wheel having a diameter, thickness and hol with one side straight or flat and the opposite side recessed. This type, however, differs from Type 5 in that tl grinding is performed by the wall (W). The wall dimension (W) takes precedence over the diameter of the recess as an essential intermediate dimension to describe this shap type.



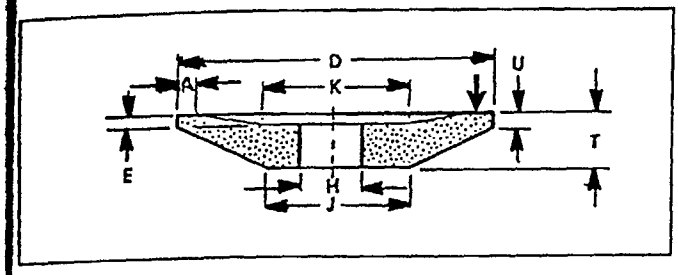
*Type 7 - Wheel, recessed two sides.
Peripheral grinding wheel having both sides recessed to allow grinding clearance for both flanges or recessed so that an unusually wide faced wheel may be mounted whe the available mounting thickness (E) is less than the over thickness (T).

Note: Arrows indicate grinding surface.
*Recess shall be at least 1/3 the wheel diameter.
"E" 5500 SFPM max.

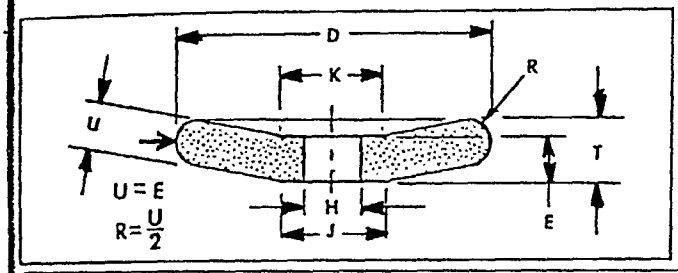
MIL 000050



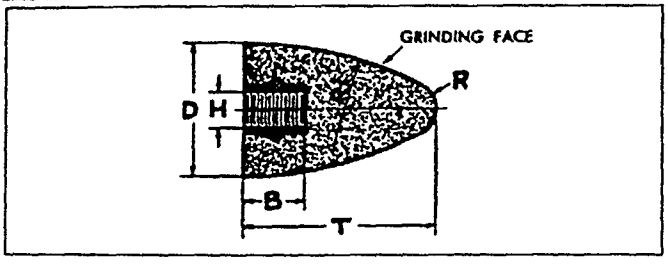
Type 11 - Flaring-cup wheel. (Print Required)
Side grinding wheel having a wall flared or tapered outward from the back. Wall thickness at the back is normally greater than at the grinding face (W).



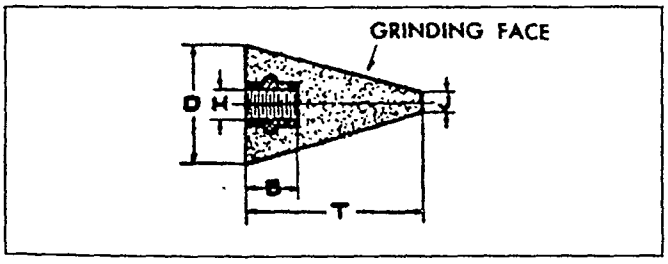
Type 12 - Dish wheel. (Print Required)
Side grinding wheel known as a dish, differing from a Type 11 in that Type 12 always has a (U) dimension. The (W) dimension of a Type 11 becomes the (A) dimension of a Type 12. The grinding may be performed by the (U) face.



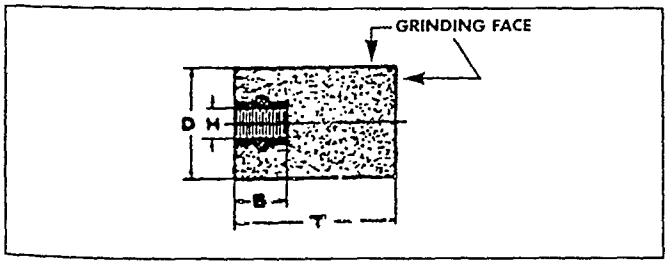
Type 13 - Saucer wheel. (Print Required)
Peripheral grinding wheel known as a saucer, differing from a Type 12 in that the cross-section is equal throughout (U=E).
The face is always half-round with R= $\frac{U}{2}$



Type 16 - Cone, curved side

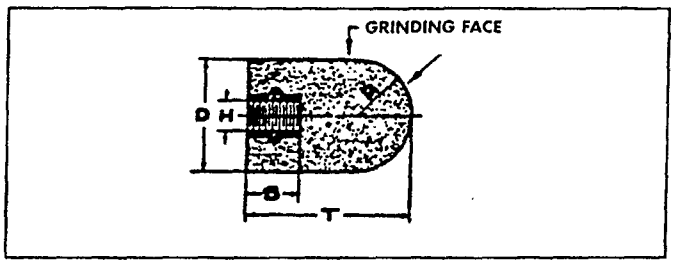


Type 17 - Cone, straight side, square tip

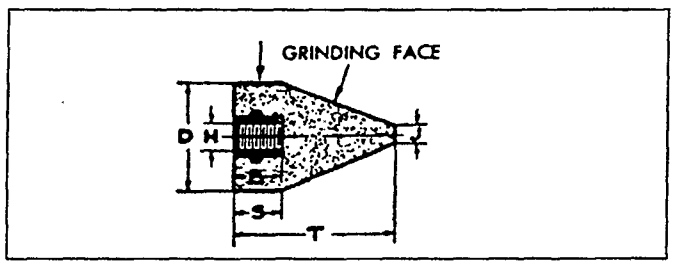


Type 18 - Plug, square end

MIL 000051



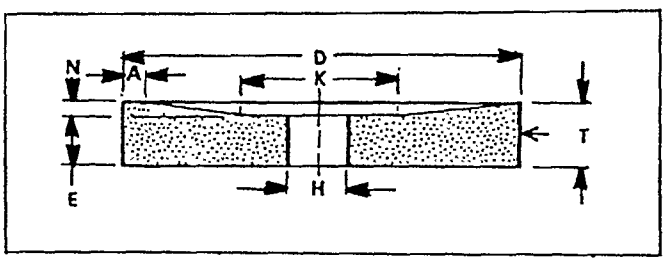
Type 18R - Plug, round end



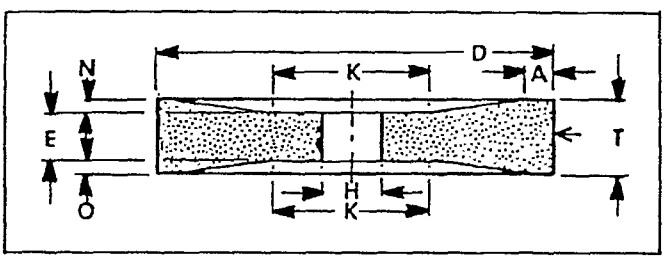
Type 19 - Plugs, cnonical end, square tip

Dished and/or Recessed Wheels

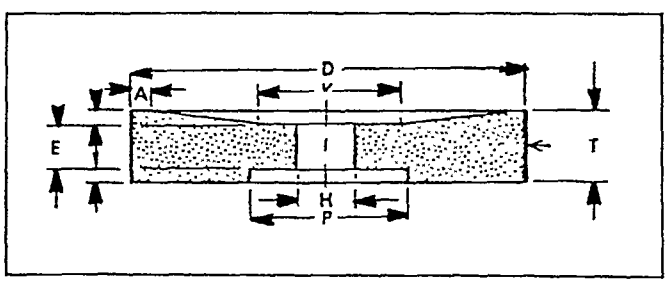
A dished side is a depression in the side of a wheel which is tapered from a radial flat at the periphery (A) to an inside flat (K) or recess diameter (P).



*Type 20 - Wheel, dished one side.
Peripheral grinding wheel having one side straight or flat and the other side dished to a flat.

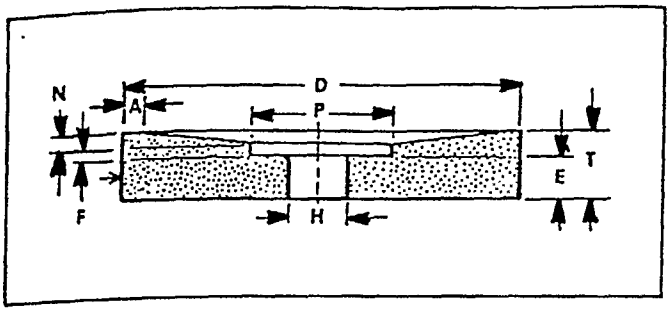


*Type 21 - Wheel, dished two sides.
Peripheral grinding wheel having both sides dished to a flat.

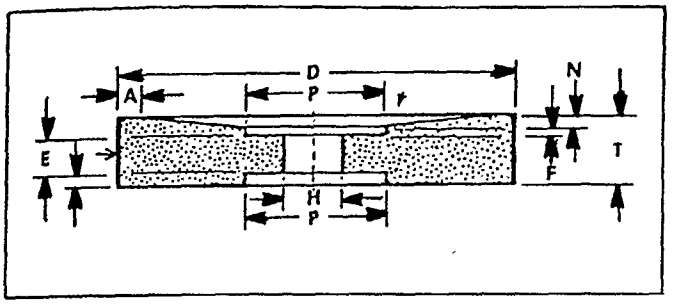


*Type 22 - Wheel, dished one side, recessed other side.
Peripheral grinding wheel having one side recessed and the other side dished to a flat.

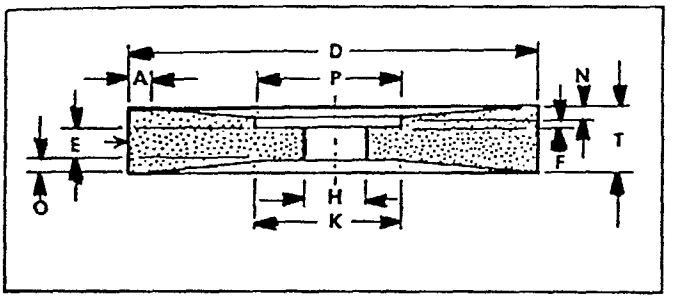
MIL 000052



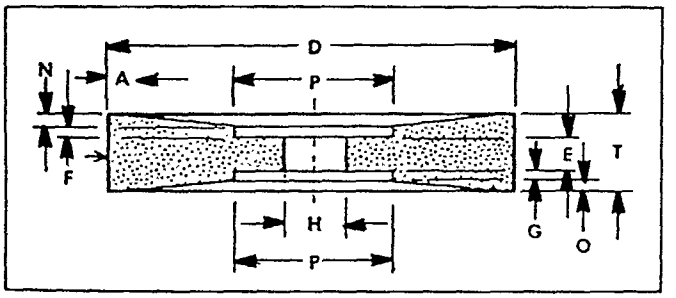
*Type 23 - Wheel, dished and recessed same.
Peripheral grinding wheel having one side straight or flat and the other side dished to a recess.



*Type 24 - Wheel, dished and recessed one side, recessed other side.
Peripheral grinding wheel having one side recessed and the other side dished to a recess.

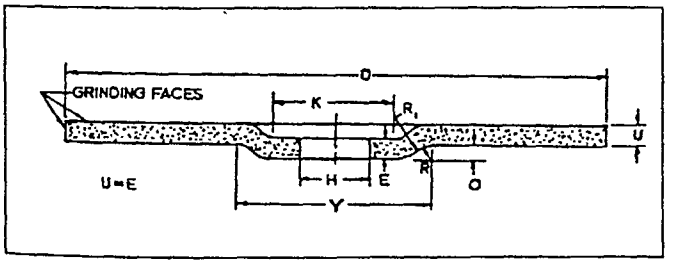


Type 25 - Wheel, dished and recessed one side, dished other side.
Peripheral grinding wheel having one side dished to a flat and the other side dished to a recess.

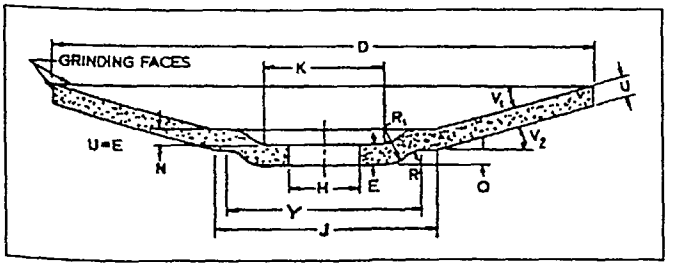


Type 26 - Wheel, dished and recessed both sides.
Peripheral grinding wheel having both sides dished to a recess.

*Recess shall be at least 1/3 the wheel diameter.
Note: Arrows indicate grinding surface.



Type 27 - Depressed center snagging wheel
Used on hand-held grinders.

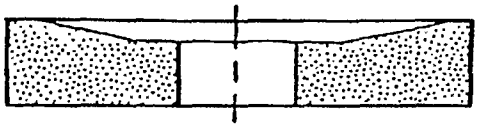


Type 28 - Dished, depressed center snagging wheel
Used on hand-held grinders.

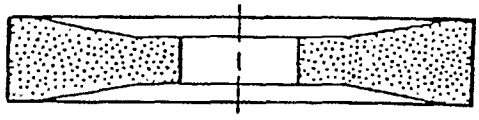
MIL 000053

How to Specify the Following Shapes:

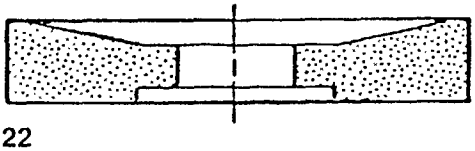
NOTE: The words RELIEVED and CONCAVE are often used instead of "Dish" in the description of types 20 through 26.



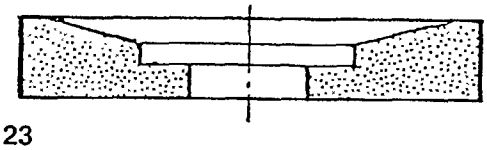
TYPE 20
Example: 20 x 2 x 12 - Grading
Rec 1/S 14-1/2 x 1/2 Dish 1/2



TYPE 21
Example: 20 x 2 x 12 - Grading
Rec 2/S 14-1/2 x 1/2 Dish 2/S 1/2

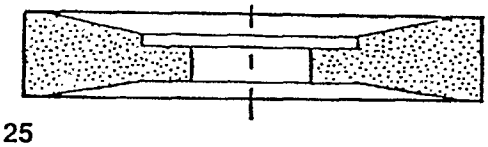


TYPE 22
Example: 20 x 2 x 12 - Grading
Rec 2/S 14-1/2 x 1/2 Dish 1/S 1/2

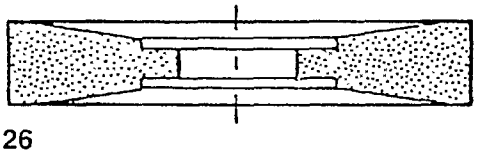


TYPE 23
Example: 20 x 2 x 12 - Grading
Rec 2/S 14-1/2 x 1 Dish1/2

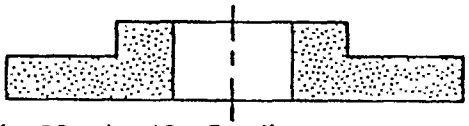
TYPE 24
Example: 20 x 2 x 12 - Grading
Rec 2/S 14-1/2 x 1/2 Dish 1/S 1/4



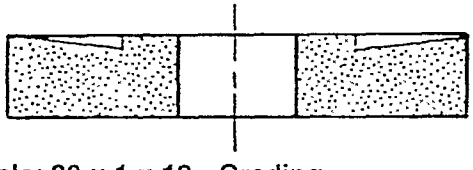
TYPE 25
Example: 20 x 2 x 12 - Grading
Rec 1/S 14-1/2 x 1/2
0/S 14-1/2 x 1/4 Dish 2/S 1/4



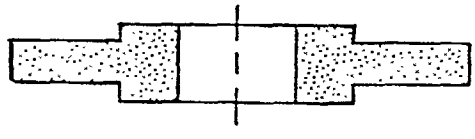
TYPE 26
Example: 20 x 2 x 12 - Grading
Rec 2/S 14-1/2 x 1/2 Dish 2/S 1/4



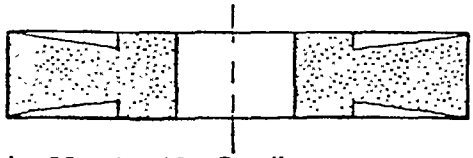
Example: 20 x 1 x 12 - Grading
15" Raised Hub 1/S-1/2" Face



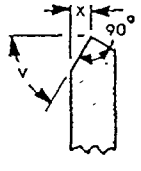
Example: 20 x 1 x 12 - Grading
Rec 1/S 1/4 to 15" Hub



Example: 20 x 1 x 12 - Grading
15" Raised Hub 2/S-1/2" Face



Example: 20 x 1 x 12 - Grading
Rec 2/S 1/4 to 15" Hub



30° Angular Grinder - V = 60°
45° Angular Grinder - V = 45°

Example: 20 x 1 x 12 - Grading
N Face X = 1/4 V = 45°

20

C-10			
THICKNESS			
MAX.	MIN.	WIDTH-W	LENGTH-L
1/2	1/8	1	3
3/4	"	3/8	4
2	"	3/4	4
2	"	1	4
1	"	2	4
2	"	2	4
1	"	7/16	6
1-1/4	"	1/2	6
1-1/4	"	1	6
2	"	2	6
1-1/8	3/16	1-1/2	7
1-1/4	"	1	8
1-1/4	"	2	8
2	"	2	8
2	"	3	8
2	"	4	8
1	"	5	8
C-11			
3/4	3/16	4	8

Average Particle Size of Abrasive Grain

This chart may be used to determine the grit size which must be specified in order to maintain a specified radius in a workpiece. If a certain radius is required, find the particle size which is the same as the radius required and specify the corresponding grit size or the next finer grit size. For example, if a .010 radius is required, specify 80 or 90 grit; or if a .003 radius is required, specify a 180 or 220 grit.

Grit Size Aluminum Oxide Silicon Carbide	Average Inches	Particle Size Microns
4	.2577	6848
6	.2117	5630
8	.1817	4620
10	.1366	3460
12	.1003	2550
14	.0830	2100
16	.0655	1660
20	.0528	1340
24	.0408	1035
30	.0365	930
36	.0280	710
46	.0200	508
54	.0170	430
60	.0160	406
70	.0131	328
80	.0105	266
90	.0085	216
100	.0068	173
120	.0056	142
150	.0048	122
180	0034	86
220	.0026	66
240	.00248	63
280	.00175	44
320	.00128	32
400	00090	23
500	.00065	16
600	.00033	8
900	00024	6
Levigated Alumina	.000118	3

Surface Finish Comparisons

Current USA *Ra (or AA or CLA) English Micro inches	Current USA *Ra (or AA or CLA) Metric Micro-meters (or microns)	Older USA RMS+Rq Micro-inches 1	W. German CH Number (or VDI #) 2 Approx. #	Soviet Class # Ra micro-meters	Swiss	French	German Micro-meters	Japan Microns
0.5	0 012	0 55		14			0.012	0 012
1	0.025	1.11		13	N1	9	0.025	0.025
2	0 050	2 2		12	N2	10	0 050	0 050
4	0 10	4 4		11	N3	11	0 10	0 10
8	0 20	8 9	6	10	N4	12	0 20	0.20
16	0 40	17 8	12	9	N5	13	0.40	0.40
21	0 80	35 5	18	8	N6	14	0 80	0 80
63	1 60	70	24	7	N7	15	1.60	1 60
125	3 2	140	30	6	N8	16	3 2	3.2
250	6 3	275	36	5	N9	17	6 3	6.3
500	12.5	550	42	4	N10	18	12.5	12.5
1000	25	1100		3	N11	19	25	25
2000	50	2200		2	N12		30	50
			1					

= 60°
= 45°

*Ra is now the universal symbol for the parameter that was called AA (Arithmetic Average) in the United States and CLA (Centre Line Average) in England.
*Also same values for Dutch RU.
1RMS 1.11 x Ra
Ra to Microns} (Ra x .0254) = MICRONS
RMS to Ra} $\frac{\text{RMS}}{1.1}$ Ra
Microns to Ra} $\frac{\text{MICRONS}}{.0254}$ = Ra
Ra to RMS} Ra x 1 1 RMS

MIL 000055

The five variables to be considered in grading a wheel are:

1. Abrasive type
2. Abrasive size
3. Hardness
4. Structure
5. Bond

Grade changes and a resultant change in grinding action can be made by variations in one or more of these components. these factors, especially Grain Type and Bond Type, will be discussed in greater depth in this section.

Abrasive

Selection of the correct abrasive for a particular job is dependent on such factors as the type and hardness of the material ground, the finish desired and the production rate required. Often, the final selection can be made only by trial on the job.

A. Conventional Aluminum Oxide Abrasives

2A — Tough aluminum oxide grain with a titanium impurity to impart toughness, used for heavy duty work (blue color).

4A — Semi-friable grain — has a sodium impurity to impart special fracture capabilities (pinkish beige color). Production and tool grinding.

12A — Semi-friable grain — has a chromium impurity to impart special fracture capabilities (pink color). Recommended for some heat sensitive steel alloys, special alloys and high chrome alloys.

9A — Pure aluminum oxide, very friable grain (white color). This abrasive is recommended for tool steels, and other heat sensitive steels.

32A — A unique single crystal aluminum oxide abrasive particularly suited for broad contact area grinding of heat sensitive alloy steels (beige in color) used extensively in tool room wheels. Only used with VFM Bond.

B. Ceramic (MSB) Aluminum Oxide Abrasive

Conventional aluminum oxide abrasives are manufactured by using an electric furnace for fusing raw materials into a large ingot. this ingot is then crushed and screened to obtain various grit sizes. Ceramic aluminum oxide (new generation abrasive) is manufactured by a sintering process. The sintered abrasive wears more uniformly and breaks down by losing smaller particles of abrasive. Significantly longer life, more parts per dress and lower power demand can be obtained with the ceramic grain. All MSB products are manufactured with a single grain size. Example: 5MSB601, 3MSB601, etc.

1MSB — A mixture of 10% ceramic (MSB) with 90% of a friable conventional abrasive (9A). Used mostly in internal wheels for I.D. grinding (light color, tinge of blue).

3MSB — A mixture of 30% ceramic (MSB) and 70% of a friable conventional abrasive (9A). For relatively low stock removal operations and relatively soft parts (light bluish color).

5MSB — A mixture of 50% ceramic (MSB) and 50% of a friable conventional abrasive (9A). For more severe operations, form holding and harder parts (blue in color).

7MSB — A mixture of 70% ceramic (MSB) and 30% of a friable conventional abrasive (9A). For operations where improvement can be obtained with a higher percentage of MSB (blue in color).

MSB — 100% ceramic abrasive. Rarely recommended. For deep slots, intricate forms, hard parts and heavy stock removal (blue in color).

C. Silicon Carbide

6C — Black silicon carbide — used for grinding non-ferrous materials and gray or cast irons.

5C — Green silicon carbide — used for heat sensitive non-ferrous materials.

7C — A 50/50 mixture of 5C and 6C.

D. Abrasive Mixtures - Conventional

For some applications, mixtures of abrasives are preferred. Mixtures of abrasives can be used to get performance-characteristics intermediate between the individual abrasives.

Mixtures for Vitrified and Resin Bond Systems

97A — A semi-friable mixture of 2A and 9A aluminum oxide abrasives (grayish in color).

29A Higher friability mixture of 2A and 9A (light gray color).

7C — A mixture of 6C and 5C silicon carbide abrasives (greenish-black in color).

MIL 000056

Mixtures for Resin Bond Systems Only

C2A — Mixture of aluminum oxide and silicon carbide - 2A and 6C.

C4A — Mixture of aluminum oxide and silicon carbide - 4A and 6C.

C12A — Mixture of aluminum oxide and silicon carbide - 12A and 6C.

C9A — Mixture of aluminum oxide and silicon carbide — 9A and 6C.

NOTE: Various blends of ceramic grains are also available for use with the resin bond system, i.e. 3MSB, 3MSBC2A, 3MSB29A, 3MSB97A, 3MSB2A.

E. Diamond

MD — Uncoated medium friability diamond for general heat sensitive carbides - wet and dry grinding.

CMD — Nickel coated diamond - wet grinding (mostly carbide).

AMD — Copper coated diamond - dry grinding of carbide.

DMD — Nickel coated blocky diamond for carbide-steel combinations.

EMD — Nickel coated friable diamond for carbide grinding (no steel) - wet.

NCD — Nickel coated diamond for difficult to grind non-ferrous materials (i.e. carbide, ceramic, glass, etc.)

F. Cubic Boron Nitride

IBN — Nickel coated CBN used in resin wheels.

BN — Nickel coated CBN used in resin bonded wheels for the toolmaster program.

2BN — Uncoated CBN used in vitrified wheels.

Grit Size

Conventional abrasives are available from coarse grit (24) to fine grit (220) mesh. The grain size in a Cincinnati wheel grade is usually a mixture of 1/3 nominal size, 1/3 next finer and 1/3 next coarser size. Example: a 60 grit wheel contains 1/3 each 54, 60 & 70 grit. Exceptions are 7C, 29A, 97A, IMSB, 3MSB. 5MSB and 7MSB. A single grit size (nominal) is used in wheels made with these abrasives. The single grit size is indicated by a 1 suffix. Example: 29A601. Superabrasives are generally available from 60 thru 320 grit.

Grades

The grade of the wheel specifies the relative amount of bond in the wheel. An M grade will has more bond than an I grade (M will act harder).

Soft grades are used on:

1. Large stock removal operations, (i.e., surface grind).
2. Large area of contact.

Hard grades are used on:

1. Low stock removal operations (finish).
2. Small areas of contact.
3. Soft materials.

Bonds

There are two generic types of bonds for precision grinding: resinoid and vitrified. Resinoid bonds are grinding wheel bonds comprised of a plastic bonding system. Vitrified bonds are grinding wheel bonds comprised of glass-like materials. Though there are no clear-cut distinctions between where resinoid and vitrified wheels are used, resinoid wheels are generally used when the wheel has to absorb some shock or operation requires that no dressing is desired throughout the useful life of the wheel. Vitrified bonds are used for form holding and high precision operations.

Resinoid Bonds

The breakdown of resin wheels in grinding is primarily from heat. Apparently the breakdown from pressure plays only a minor role in resins; however, pressure is a major factor in vitrified breakdown. This (in part, at least) explains why these bonds do not act the same in grinding grade for grade, and why the grade pattern cannot be compared one with the other. To further the confusion, competitive resinoid grading systems and our own agree less among themselves that they do vitrified. For this reason it is seldom wise to rely too heavily on competitive gradings. Although we do not agree with competition, we do have a regular progression in hardness from grade to grade which is not generally common with other manufacturers.

Resin bonds in general have a much higher resistance to *thermal* shock than do vitrified and are therefore to be used on all *dry, high stock removal* operations to the exclusion of vitrified bond.

Resin bonds are better able to absorb mechanical vibrations and are for this reason preferred in many finishing operations where fine grain wheels are used (120 and finer). The coarser grain sizes are usually avoided in finishing because of the tendency of resins to "fish tail", leaving deep scratches in the surface.

There is another important difference between resin and vitrified bonds in application. It is usually easy to determine the *hard* or *soft* action of a vitrified wheel; however, this is not always true of resin. A resin wheel will often *act soft* when it is in fact *too hard.* This stems from the fact that resins break down from heat. The harder the wheel, the more heat developed - and hence more breakdown. There is no easy way to analyze this type of problem except to say that if several wheels have been tried, each harder in grade than the preceding wheel, and all act soft, it is often wise to try grades *softer* than the softest grade tried.

Unlike vitrified bond wheels, resin bond wheels cannot be checked for cracks by ringing them with a mallet. All resin wheels should be given a careful visual inspection before mounting.

Wet or Dry Grinding

Resin bonds give best results when the bond is designed for either wet or dry grinding. Some resins have better wet strength, others better heat resistance. Precision grinding with rare exceptions is always done wet. Resin bonds used in precision grinding are designed to resist breakdown from the various coolants which can be used. Cut-off operations can be done either wet or dry.

B2 — General purpose bond used mostly in precision grinding operations. Can also be used in cut-off applications, wet or dry where a soft acting bond is required — especially useful on heat sensitive materials.

B90 — A recently developed (Excalibur) general purpose bond which has proven to be more consistent in precision grinding applications with longer wheel life compared with similar wheels made with B2. Competes with Norton's B17.

B5 — Bond system specifically designed for flute grinding.

BHT — Bond system specifically designed for thread grinding.

B8 — Warm pressed bond system used in non-reinforced cut-off wheels. Harder acting compared to B2.

BF9 — A bond system designed for use in reinforced cut-off wheels.

BPN — Bond system for use in an economy line of non-reinforced cut-off wheels.

BPY — Bond system for use in an economy line of reinforced cut-off wheels.

B9 — Cold press cut-off.

B2 — Hot press cut-off.

BB — Bond system designed for use in mounted points.

BX — Resin bond system used for deburring and very light stock removal. Very limited availability. Some A, B and W shape mounted wheels and some small diameter Type 1 wheels. Cotton fiber reinforced.

BXP — Softer and more resilient bond than BX. Best suited for polishing. Also very limited availability. Cotton fiber reinforced.

Special Resilient Bonds

BWK — Resin modified bond used in light stock removal, precision grinding applications.

BR — Resin modified bond designed for use in regulating wheels.

Rubber Bonds

R — General purpose rubber bond for cut-off wheels where burr and burn free parts are essential, regulating wheels and mounted points

Vitrified Bonds

VFM — General purpose bond system for precision grinding. Used with aluminum oxide only.

VFMEI — VFM bond used in special regulating wheel applications (lappers).

VRW — General purpose bond system for precision grinding with excellent form holding capabilities. Used with aluminum oxide only.

VQC — General purpose bond system designed for high production centerless, large centertype and microcentrics (available with 2A, 29A, 97A and 12A abrasives).

VL — Surface grinding bond. General use would be in segments and larger wheels (20" x 24" O.D.). Used only with aluminum oxide abrasive.

VA — Bond system used where softer, cooler cutting action is required, e.g. burn sensitive, thin wall parts. large parts. Works extremely well with 29A abrasive.

VSA — Bond system specifically designed for MSB abrasive and mixtures of abrasives containing a portion of MSB

VCR — Bond system specifically designed for use in creepfeed grinding wheels. Used with both aluminum oxide and silicon carbide abrasives.

V4 — A low temperature bond used largely in creep-feed and surface grinding applications.

VC — A very similar bond to be used when grain size is 54 and finer.

VF — Similar to VC. To be used when grain size is 60 and finer.

VCO — Bond system used exclusively for segments. Limited availability. AA-1, CD universal, NO Universal and HM14 styles only. 2A, 97A, 9A and 12A abrasives only.

VFP — Bond used in products with engineered grain spacing. Pores are generated by burn out during firing of an organic material which is uniformly distributed in the wheel. Use only with aluminum oxide abrasives.

VFQ — Another bond used in products with engineered grain spacing. Unlike VFP products, the pore inducer does not burn out, but is a soft material uniformly dispersed in the wheel which crushes easily during grinding creating the effect of porosity. Use only with aluminum oxide abrasives.

VE0615 — Bond symbol for VFM wheels for operation at 16000 SFPM.

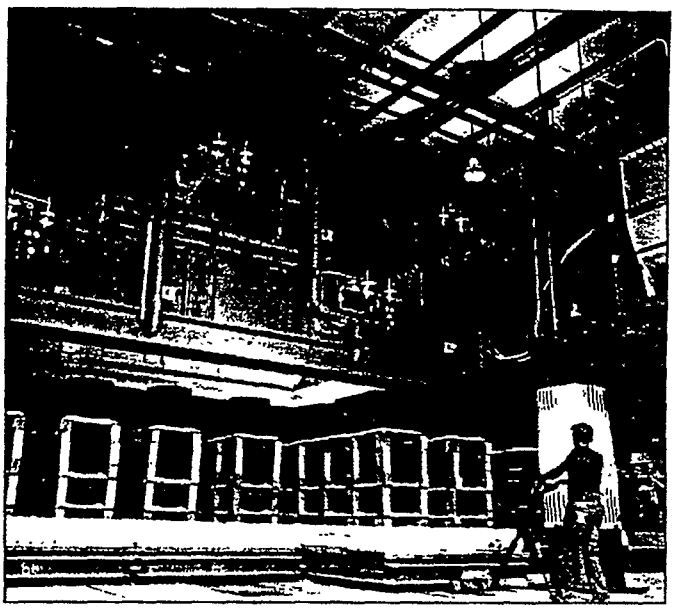
VE0685 — Bond symbol for VRW wheels for operation at 16000 SFPM.

VSC — General purpose bond used only with silicon carbide abrasives.

V5 — Tough mounted point bond used with aluminum oxide abrasives.

V6 — Glossy mounted point bond used in precision operations with aluminum oxide abrasives.

V7 — General purpose bond for use in mounted points with silicon carbide abrasives.



MIL 000059

Grinding Wheel Treatments

For certain purposes grinding wheels are impregnated with material designed to aid or improve the grinding action. This is called "treating" the wheel. Treatment will improve the grinding action by:

1) Reducing loading. Loading is buildup of metal on the abrasive surface resulting from working soft and ductile metals such as aluminum, soft bronze, brass, magnesium, etc. The use of special treatment fills the pores and helps to prevent swarf buildup.

2) Improving cutting action and life. On heavy duty operations sufficient heat is generated to soften the treatment so that it flows and has lubricating action.

3) Changing the grinding action. This means increasing wear resistance without affecting the rate of cut or burning the work.

4) Helping to maintain and hold form on shaped wheels. Filling the pores adds support to the abrasive grains.

5) Sealing the pores - or waterproofing bonded abrasive products.

How to Order Treated Wheels

Treatment designation is shown in the marking as follows:

14 x 2 x 1¼ - 97A601-K6-VFMD2
1 x 1 x 3/8 - 9A80-M4-VRWD2

D - Wax
B - Sulphur
D2 - Special Impregnation

Availability

Basically there are three types of treatments being applied to CINCINNATI Grinding Wheels today. These are:

D - Wax
B - Sulphur
and a special impregnation called D2

Contact your Cincinnati Milacron Marketing Company, Territory Manager or Application Engineer to determine the exact sizes and specifications for which these treatments are available.

WAX - D Treatment includes parafins, and stearates. This type of treatment is used on applications to retard wheel loading.

SULPHUR - B Treatment is by far the most widely used It finds extensive use in the bearing industry on high-production, fast stock removal, internal grinding operations. The automotive industry also uses sulphur treatec wheels. As much as 70-80% of all honing sticks are sulphur treated. Most vitrified bonded cutlery grinding wheels are sulphur treated.

Sulphur treatment is not available in organic bonds. Better surface finishes can be produced with sulphur treated wheels than with wheels having no treatment.

D2 Treatment (proprietary) - Another popular treatment used largely in the bearing industry on high-production bore and race grinding operations. It does not have the stain and odor characteristics found in sulphur, but does add cooling and lubrication to the grind.

Prices

The prices of treated wheels are 5 to 15 percent higher than those of the same wheels untreated. Sulphur treatment is not available in VRW or VQC bond.

Standard Treatments for Vitrified Bonded Products

For VFM, VL and VSC Only
Exception: D2 is available in VRW and VQC
"B" Treatment - Sulfur Impregnation
"D" Treatment - Wax Impregnation
"D2" Treatment - Special Impregnation

"R" Treatment - Resin Impregnation for Mounted Wheels
"S" Treatment - Wax Impregnation for Mounted Wheels

Treatment	Availability
"B"	Wheels 18" O.D. and Smaller, 3" Thick and Thinner 70 Grit and Finer, H Grade and Harder NOT AVAILABLE IN VRW, VSA
"D"	Wheels 6" O.D. and Smaller, 4" Thick and Thinner Over 6" thru 30" O.D., 2" Thick and Thinner NOT AVAILABLE IN VRW, VSA
"D2"	Wheels 30" O.D. and Smaller, 3" Thick and Thinner 46 Grit and Finer, 4 and 6 Structure

NOTE: Treatments are not available for plate mounted and n. inserted disc wheels

CIMFORM® GRINDING WHEELS
CINCINNATI MILACRON MARKING CHART

ABRASIVE SYMBOL		GRIT SIZE				GRAIN COMB.	GRADE			STRUCTURE			BOND		BOND SUFFIX
		COARSE	MEDIUM	FINE	VERY		SOFT	MEDIUM	HARD	DENSE	MEDIUM	OPEN	VITRIFIED	RESINOID	
A, AK	Blue	10	30	90	FINE	1	C	J	P	3	6	9	V	B2	Treatment No. 1 - Graph
2A, FA	Blue					2							V2	B238	Treatment No. 2 - Wax
9A, 10A, WA	White	12	36	100	240		D	K	Q	4	7	10	V2P	B254	B - Sulphur
11A, 32A	Tan					3							V3	B291	D - Wax
12A, 13A, 82A	Pink	14	46	120	280		E	L	R	5	8	11	V5	B320	D2 - Special Treatment
29A, H5A, HA	Lt Grey					4							V6	B5	
97A	Grey	16	54	150	320		F	M	S			12	V7	B8	1 - 1/4 Grade Harder
LA	Off White					5							VA	B80	2 - 1/2 Grade Harder
JA	Off White	20	60	180	400		G	N	T			13	VC	B9	3 - 3/4 Grade Harder
E5A	Mixture A/O & SIC					6							VCR	B90	4 or Blank - On Grade
H5A	Mixture A/O	24	70	220	500		H	O	U			14	VF	BA	
AZ	Premium Zirconia Alumina					7							VFM	BZ	-55 Fine Grooves
18A	Zirconia Alumina/A		80		600		I		V			15	VFME1	BC	-66 Smooth Sides
W5A	Zirconia Alumina/A					8							VGF	BF	-77 Coarse Grooves
15C	Zirconia Alumina/SIC				900				W			16	VK	BF9	-88 Rough Sides
18C	Zirconia Alumina/SIC					9							VKP	BFG	-99 Tefglass Sides
W5C	Zirconia Alumina/SIC				1200				X				VL	BH	
15A	Zirconia Alumina/A												VLE1	BHJ	
C, CK, 6C	Black SIC								Y				VOC	BPN	
GC, 5C	Green SIC												VRW	BPY	
FC, 7C, RC	Mixture SIC								Z				VSA	BR	
C2A, R5A	2A/6C Mixture												VSC	BWE1	
C4A	4A/6C Mixture												VXP	BWK	
C9A	9A/6C Mixture												VSK	BX	
C12A	12A/6C Mixture												RUBBER	SHELLAC	
1MSB	10% Synthetic Grain & 9A												R	E	
3MSB	30% Synthetic Grain & 9A														
5MSB	50% Synthetic Grain & 9A														
7MSB	70% Synthetic Grain & 9A														
MSB	100% Synthetic Grain														
3MSB2A	30% Synthetic Grain & 2A														
3MSB29A	30% Synthetic Grain & 29A														
3MSB6C	30% Synthetic Grain & 6C														
3MSB97A	30% Synthetic Grain & 97A														
3MSBC2A	30% Synthetic Grain & C2A														
WB	50% Ceramic Grain & WA														
3WB	33 3% Ceramic Grain & WA														
DA	25% Ceramic Grain & 2A														

Typical Marking: **29A _ 60 _ 1 _ K ___ 6 ___ VFM _ D2**

CIMFORM GRINDING WHEELS
CINCINNATI GRAIN TYPES

MFG	Premium Zirconia Alumina	Zirconia Alumina	Regular	Semi Friable	Friable White	Pink	Off White/ Tan	AO Mixture	SC/AO Mixture	SC Heavy Duty	SC Regular Black	Friable Green	SC Mixture	Synthetic Abrasive
CINCINNATI MILACRON	AZ	18A, W5A 15A	A AK FA	2A	9A 10A WA 10AK	12A 82A 13A	32A 11A	29A, 97A H5A, 2A, HA, LA, JA, H5AK	CA C2A, C4A C9A, C12A E5A, R5A, R5AK	15C, 18C W5C	6C C CK	5C GC	7C FC RC	MSB, 1MSB, 3MSB, 5MSB, 7MSB, 3MSB2A 3MSB29A, 3MSB97A, 3MSBC2A 3MSB6C DA, WB, 3WB
Acme		3XT, 2XT, 8XT	A, FA					WA	CA, C1A, C2A		C	GC		
Allison Abrasives			A, TA, TDA		WA			W4A	CA	C	GC			
Bay State		27A, 33A	A	3A	9A	17A	19A	8A, 2A, 16A	CA, MA	7C	C	1C	3C	1GA, 3GA, 5GA, GA
Buckeye		ZR, ZRA, ZRC	A, FA		WA			MA	CA	HC	C	GC		
Carborundum		AZA, VA	A, GA		AA	BA, PA		DA	CA	TC	C	GC	RC	
Colonial			A	TA	20A	51A, 24A, 25A		5TA, 10TA, 15TA, 22TA, 26A	5TAC 10TAC		C	GC	CGC	
Gardner			A, 84A, 82A		80A			18A, 88A, 85A	AC		C	GC	SC	
Hanson		ZA	TA, 8A		WA	RA		HA, W2A	CA, AC		C	GC	4C	
Jowitt Rodgers			G, A		W			AW	AX		X	GC		
MWA			1A, 8A	2A	29A		SFA, S11A	8AC, 11AC	C	3C	7C			
National		24A, ZA	A, PA		SA	WA	BA	MA, HA	CA, CKA		C	GC	RC	
Norton	NZ, NZC	ZF, 3ZF, ZS 4ZF, 5ZF	A, 76A	57A, U57A	38A	25A, 64A, 86A	32A	16A, 19A 23A, 53A	AC		37C	39C	74C	1SG, 3SG, 5SG SG
Pacific		19A, 20A, 21A	A	35A	50A	49A	47A	40A, 42A, 45A, 46A	69A, 70A, 71A, 72A 73A		75C	80C	77C	
Radac		YA, YB YD	A, TA, BA	9A, WA	RA, WRA	AT		9RA, WAA, 97A, RFA, RAA, 7RA, 43A, 45A	CA 41C, 42C		C	GC	8C	1GA, 3GA, 5GA
Red Hill		ZA, XA	A, FA	WA			HA	AC		C	GC			
Sterling	A	VA, VA2	A	KA	WA	OA		ZA, EA, PA	JA		C	GC	SC	
Tyrolit	28A	21A	A		89A	88A	90A, 91A				1C	C	50C	97A
Winterthur			A	31A	9A, 53A	57A, 68A		61A, 64A, 67A	AC		C	11C		

CINCINNATI BOND COMPARISONS

CINCINNATI MILACRON	VL	VFM V6, VK VC, VF, V9	VQC V3	VRW	VCR VKP VP3	VA V, V9	VSC VS V	VSA V, VC, VF	B2 B9	B80 B238 B320	B90, BA BC, BF BH, B254	BWK B291	B5	BZ
Acme										B4A, B6A				
Allison Abrasives									B1, B4, B6, B6A					BHF
Bay State		V22, V52, VA2 V52KS V62	V76	V76	KOOLPORE VHP, VTP		V32	V89	B24, BD 8P2	BJ2	B, B5, B11 BA2, BC2		B02	BRSAA
Carborundum	V10	V14, V20 VT		V30 V60	V40		VR, VUF V VO, VGC		B5SW B5RW				BT	BT BFC
Colonial		VS, VSD1			VSP		VS1, V12C		BSL1, BSL2		BSL3 BSL4			
Gardner											B, BK, BW BEX			
MWA	V VC VRC	V1 VF			VF1P VMM		VS, VBS VY							
National	V3	V6W							BCP	BB	BX			
Norton		V8E	V8E	V127, V128	VCF		V VK (+1)	VS	B B17 B24	B25 B25W	BH	B24	BX354	BNC
Pacific	VA3 VS5						VS8				BB BB2			
Radiac	V	V V1 V3 V8 VW			VOS VP		V9 VD6	VOS V8	B3 B30 B36		BFM		BF	
Sterling	VA V25	VH3 V6			V2P		VM VC		B, BFC BT BT8	BF		BAF		
Tyrolit		V						V	B					
Winterthur		V							B					

CIMFORM® GRINDING WHEELS
SUPERABRASIVE MARKING CHARTS

RESIN BOND DIAMOND WHEELS

GRIT TYPE		GRIT SIZES	GRADES	CONCENTRATIONS	BOND	DEPTH OF DIAMOND
MD	Uncoated	46 thru 600	Soft-J-L-N-P-R-Hard	Low-50-75-100-High	B, BY	
CMD	Nickel Coated	46 Thru 320	J-L-N-P-R	50-75-100	B, BY	
AMD	Copper Coated	46 thru 320	J-L-N-P-R	50-75-100	B5, B5Y	****
DMD	Nickel Coated	60 thru 320	J-L-N-P-P	50-75-100	B6, B6Y	
EMD	Nickel Coated	60 thru 320	J-L-N-P-R	60-75-100	B, BY	
NCD	Nickel Coated	100, 150, 220	P-R	75-100	BDL	

RESIN BOND CBN WHEELS

GRIT TYPE		GRIT SIZES	GRADES	CONCENTRATIONS	BOND	DEPTH OF DIAMOND
1BN	Nickel Coated	46 thru 320	Soft-M-O-Q-S-U-Har	Low-80-100-High	B4, B4Y	
1BN	Nickel Coated	46 thru 320	Q - Light Duty T - General Purpose W - Heavy Duty	Q=44 T=66 W=88	B7	****
BN	Nickel Coated	100, 150, 220	Q - Light Duty T - General Purpose W - Heavy Duty	Q=44 T=66 W=88	BBL	

VITRIFIED BOND DIAMOND WHEELS

GRIT TYPE		GRIT SIZES	GRADES	CONCENTRATIONS	BOND	DEPTH OF DIAMOND
RD		60-320	M-N-O	50-75-100	VDA	****

VITRIFIED BOND CBN WHEELS

GRIT TYPE		GRIT SIZES	GRADES	CONCENTRATIONS	BOND	DEPTH OF DIAMOND
2BN	Uncoated	60 thru 320	P-R-T-U	100-125-150	VHA	****
2BN	Uncoated	60 thru 320	P-R	100-125-150	VHC	

VITRIFIED BOND OPEN STRUCTURE CBN WHEELS

GRIT TYPE		GRIT SIZES	GRADES	CONCENTRATIONS	BOND	DEPTH OF DIAMOND
2BN	Uncoated	60 thru 320	M-N-O-P	80-100-125-150	VEA	
2BN	Uncoated	60 thru 240	M-N-O	100-125-150	VEC	
2BN	Uncoated	60 thru 320	M-N-O-P	164	VEB	****
2BN	Uncoated	60 thru 240	M-N-O	100-125-150	VMA	
2BN	Uncoated	60 thru 240	M-N	100-125-150	VMC	
2BN	Uncoated	60 thru 240	M-N-O	164	VMB	

CIMFORM GRINDING WHEELS
SUPERABRASIVE CONVERSION CHART

CINCINNATI MILACRON	MD	CMD, NCD	AMD	DMD	EMD
Abrasive Technology	S	SN	SC		
Accurate Diamond Tool	D, MD	NCD	CCD		
Bay State	D, 6D	D, 4D, 7D	3D	9D	
Ceram	DU	DN, DX	DC		
Citco	SD	5SD	9SD	6SD	4SD
Clipper	MD	MDN	MDC		
Construction Diamond Products	MD	ND	CD		
Continental Diamond Tool Corp.	MD	NDC	CCD	CSGD	NC8D
Diamond Productions Inc.	D, MD	ND	CD		
Diamond Technology Products Ltd.	MD	CMD			
Elgin	D, MD	CD	CDC	AGB	
Engis	D, MD	NMD	CMD		
Fantastic	SD	CD			
General Industrial Diamond Co.	GD	CGD	CGBD	XD	
Jacques	S	SN	SC		
Kennametal	SD	CD	CCD	CDX	CDP
National/U.S. Diamond	D, MD	MDC, WD	DD, MDK	DSC, MD4C	8WD
Noritake	SD	SDC			
Norton	SD	ASD	ASDC	AMD	A2D
Pacific	MD	NMD	CMD		
Permattach	PDM, PDN	PBB			
Precision	MD	ND	CD	XD	
Radiac	D, MD	NCD, WD, 1WD	CCD, DD	SD	
J.K Smit	6, 6D	PD	PDC		
Superabrasives, Inc.	D, MD	MDN	MDC		
Supercut	E	C, H	D	F	
Tyrolit	SD	SDM	SDC	SDX	
Union Dia-Tek	D, 1D	2D	3D	5D	4D
Univel	E	G	K	H	
Universal (Radiac)	MD	WD	DD		
U.S. Diamond (See National)					
Waltham	MD	ND	CD		
Wheel Trueing	WD, WMD	WCMD			
Wickman	SD	XDN	SCD	DXD	PDN

Superabrasive Conversion Chart — CBN

CINCINNATI MILACRON	2BN	1BN
Abrasive Technology	CB	CBN
Accurate Diamond Tool		BN
Amplex		CB
Bay State	1B,GSS	2B, B, KSS
Carborundum	CB	
Ceram		CB
Citco		CB
Clipper		CB
Construction Diamond Products		CB
Continental Diamond Tool Corp.	BZ	
Diamond Products Inc.		CB
Diamond Technology Products Ltd.	BN	CB
Elgin		CBN, BZN
Engis	B	

General Industrial Diamond Co.		CB
National/U.S. Diamond		B, CB
Norton	B	CB
Permattach		PBM
Radiac		BZ
Regal Diamond		B, BB
Superabrasives, Inc.		BN
Supercut		B
Tyrolit		BM
Ultra Diamond	CBN	2CBN
Union Dia-Tek		CB
Univel		B
Universal (See Radiac)		
U.S. Diamond (See National)		
Waltham		BN

CMSA II Synthetic Abrasives

CMSA II synthetic abrasive grinding wheels consistently outperform other wheels in productivity, cost efficiency and versatility. Performance generated by CMSA II on most grinding operations exceeds Milacron standards by as much as 30% to 40%. CMSA II is as versatile as it is innovative; the ideal, high performance grinding wheel for basic and precision grinding applications.

Grinding System Engineers

Our Grinding System Engineers are ready to help you optimize your grinding operation utilizing the complete line of Milacron abrasives and CIMCOOL metalworking fluids. After reviewing your total grinding operation our GSE will recommend and apply the products designed to achieve greater productivity and higher efficiency. We guarantee that CMSA II will deliver many advantages to your grinding applications, including superior quality on your finished parts.

CMSA II Grinding Application Advantage

- More pieces per dress
- Less diamond wasted
- Cooler cutting
- Better part to part consistency
- Less chatter
- Better geometry
- Less downtime
- Better finishes
- Faster cycles
- Free cutting
- Less burn
- Broader range of applications
- Better form holding

Current Status of CMSA II

1. In general, MSB Wheels perform very well.
   A. 30% MSB outperforms 50% SG wheel.
   B. 30% MSB outperforms a conventional wheel up to 65 times.
2. MSB Segments perform well on hard materials.
3. Creepfeed-Grade MSB Wheels are successful on aerospace materials.
4. Highspeed MSB Wheels (16,000 SFPM) demonstrate outstanding grinding performance and wheel life.

Patents Related With CMSA II

A. MSB Grain
   U.S. Patent No. 4,881,951, 11/21/89, 3M Co.
   U.S. Patent No. 5,282,875, 2/1/94, 3M Co./Cincinnati Milacron

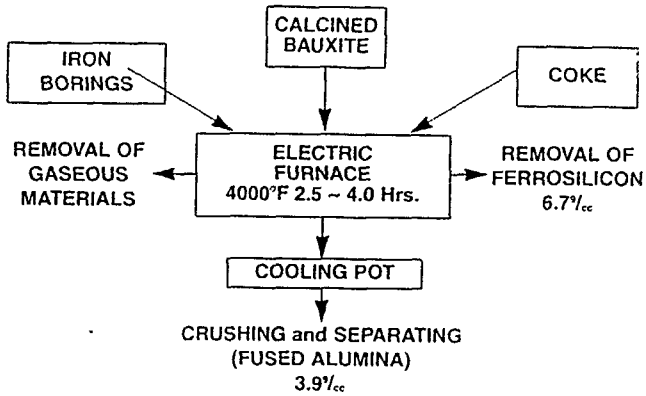
B. Organic Pore Inducer
   U.S. Patent No. 5,037,452, 8/6/91, Cincinnati Milacron

C. Inorganic Pore Inducer
   U.S. Patent No. 5,094,672, 3/10/92, Cincinnati Milacron

Comparison — Aluminum Oxide Abrasives

	FUSED ALUMINA	SOL-GEL ALUMINA	
		SG GRAIN	MSB GRAIN
1. Manufacturing Process	Fusion	Sol-Gel	Sol-Gel
2. Crystal Size (um)	~200	~0.2	~0.05
3. No. of Crystals/60 Grit	~1	~1 Billion	~64 Billion
4. Reinforcing Structure	No	No	Yes

A. Fusion Process



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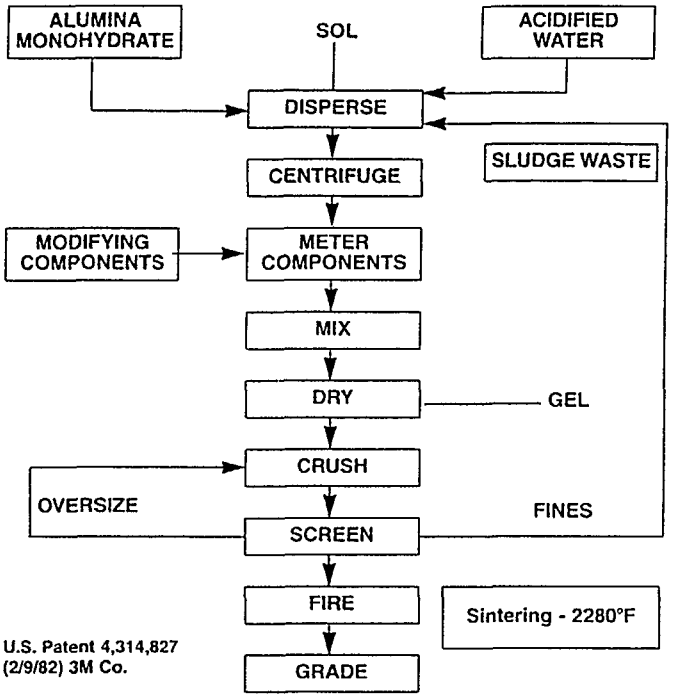
(B) Sol-Gel Process



U.S. Patent 4,314,827
(2/9/82) 3M Co.

Valve Manufacturer
- 3MSB601-N 4/2 VSAE 9581
- 24 x 1 x 12 Engine Valve
- XA706-P6-VH2
- PPD Increased 5 times
- 20% shorter cycle

Automotive Engine
- 5MSB541 K6 VSAE 15 Cranks PD
- 42 X 1.880 X 12.050
- 53A54 M VSB Crank Pin
- 53A 2 cranks per dress
- 7.5 times better

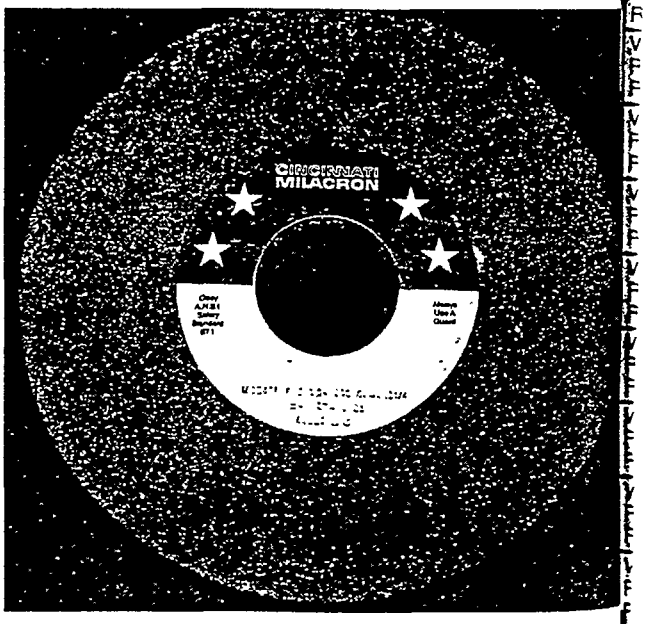
Transmission Parts
- 3MSB 801A-J6-VSAE 100 PPD @ .0004
- 24 X 1.388 X 12
- 97A801-J-VQC 7 PPD @ .0008
- 29 times better

MSB Case Histories

Diesel Engine Parts
- 2MSB461 L6 VSA 42 x 2.130 x 12
- 29A461-M6-V72 BS
- Crank Pins
- 3PPD MSB AT .00125
- 1PPD 29A AT .00250
- Overall 6 times better

Engine Builder
- 3MSB801 N4 VSAE 36.024 x .925 x 12
- 9A70 O4 VFME
- 9PPD MSB Crank Pin
- 2PPD 9A
- 4.5 times better

Engine Builder
- 3MSB601-N6/3MSB601-K6VSAE
- 42 X 2.002 X 12.050
- 57A54-L-VSB
- Better finish; 4 times better life



MIL 000066

WEIGHTS OF ALUMINUM OXIDE* GRINDING WHEELS WITHOUT HOLES

Diameter		Thickness (Inches)							
		1	2	3	4	5	6	7	8
Vit.	1	.07	.13	.20	.27	.33	.40	.47	.54
Res.	1	.08	.16	.23	.31	.39	.47	.55	.62
Rub.	1	.09	.17	.26	.34	.43	.51	.60	.67
Vit.	11/2	.15	.30	.45	.60	.75	.90	1.2	1.2
Res.	11/2	.17	.34	.51	.68	.85	1.0	1.2	1.4
Rub.	11/2	.20	..40	.60	.80	1.0	1.2	1.4	1.6
Vit.	2	.28	.56	.84	1.1	1.4	1.7	2.0	2.2
Res.	2	.31	.62	.93	1.2	1.6	1.9	2.2	2.5
Rub.	2	.34	.68	1.0	1.4	1.7	2.0	2.4	2.7
Vit.	3	.60	1.2	1.8	2.4	3.0	3.6	4.2	4.8
Res.	3	.69	1.4	2.1	2.8	3.5	4.2	4.9	5.6
Rub.	3	.76	1.5	2.3	3.1	3.8	4.6	5.3	6.1
Vit.	4	1.1	2.1	3.2	4.3	5.4	6.4	7.5	8.6
Res.	4	1.2	2.5	3.7	4.9	6.2	7.4	8.6	9.9
Rub.	4	1.4	2.7	4.1	5.4	6.8	8.2	9.5	10.6
Vit.	5	1.7	3.3	4.9	6.6	8.3	10.0	11.6	13.3
Res.	5	1.9	3.9	5.8	7.7	9.7	11.6	13.5	15.5
Rub.	5	2.1	4.2	6.4	8.5	10.6	12.7	14.8	17.0
Vit.	6	2.4	4.8	7.2	9.6	12.0	14.4	16.8	19.2
Res.	6	2.8	5.5	8.3	11.1	13.9	16.6	19.4	22
Rub.	6	3.1	6.1	9.2	12.2	15.3	18.3	21.4	24
Vit.	7	3.3	6.5	9.8	13.1	16.3	19.6	22.8	26
Res.	7	3.8	7.6	11.4	15.3	18.9	22.7	26.5	30
Rub.	7	4.2	8.3	12.5	16.6	20.8	25	29.1	33
Vit.	8	4.3	8.5	12.8	17.1	21.3	26	30	34
Res.	8	4.9	9.9	14.8	19.9	24.7	30	35	39
Rub.	8	5.4	10.9	16.3	21.7	27	33	38	43
Vit.	9	5.4	11	16.2	21.6	27	32	38	43
Res.	9	6.2	12.5	18.7	25	31	37	44	50
Rub.	9	6.9	13.7	20.6	27	34	41	48	55
Vit.	10	8.3	13.3	20	27	33	40	47	53
Res.	10	9.7	15.6	23.3	31	39	47	54	62
Rub.	10	10.6	17.0	25	34	42	51	59	68
Vit.	12	12	19.2	29	38	48	58	67	77
Res.	12	13.9	22.2	33	44	55	67	78	89
Rub.	12	15.2	24.4	37	49	61	73	86	98
Vit.	14	13.1	26.1	39	52	65	78	91	105
Res.	14	15.2	30.4	46	61	76	91	106	122
Rub.	14	16.6	33.2	50	67	83	100	116	133
Vit.	16	17.1	34.1	51	68	85	102	119	136
Res.	16	19.7	39	59	79	99	118	138	158
Rub.	16	21.7	43	65	87	109	130	152	174
Vit.	18	21.6	43	65	86	108	130	151	173
Res.	18	25	50	75	100	125	150	175	200
Rub.	18	27	55	83	110	138	165	192	220
Vit.	20	27	53	80	107	133	160	187	214
Res.	20	31	62	92	123	154	185	216	247
Rub.	20	34	68	102	136	170	204	238	272
Vit.	22	32	65	97	129	162	194	226	248
Res.	22	38	75	112	149	187	224	261	298
Rub.	22	41	82	123	164	205	246	297	328
Vit.	24	36	77	115	164	192	230	269	307
Res.	24	45	91	136	182	227	272	318	363
Rub.	24	49	98	147	195	244	293	342	380
Vit.	26	45	91	135	180	255	270	315	360
Res.	26	52	104	156	208	260	312	364	416
Rub.	26	57	115	172	229	286	344	401	457
Vit.	28	52	105	157	209	261	314	366	418
Res.	28	62	123	184	246	307	368	429	491
Rub.	28	66	133	199	266	332	399	465	531
Vit.	30	60	120	180	240	300	360	420	480
Res.	30	70	141	211	282	351	422	492	563
Rub.	30	76	153	239	305	380	458	534	610
Vit	36	86	173	259	345	432	518	604	690
Res.	36	99	200	300	400	500	600	700	800
Rub.	36	109	220	330	439	549	659	768	878

)educt 10-15% for silicon carbide wheels

HOW TO USE THIS CHART

A table of grinding wheel weights can only be approximate due to the many variations of abrasives, grains and grades and bonding processes. This table may be used in estimating net weights of wheels for shipping or ordering purposes, or for calculating approximated floor loads.

As the chart covers wheels without holes, net weights shown for a wheel equivalent to the hole diameter and thickness should be deducted e.g. 1 - 20 x 2 - 12 Alum. vit.

20 x 2 = 53 lbs.
12 x 2 (hole) = 19.2
Net Weight = 33.8 lbs.

to find the total weight of a package add 20% to the net weight of the quantity involved. In the above example for 1 - 20 x 12 wheel weighing 33.8 lbs. net add 20% or 6.76 lbs. for packing material and container resulting in a gross weight of 40½ lbs.

When wheels are recessed on one or both sides the weight of a wheel equivalent to the diameter and thickness of each recess should also be deducted. For example:

1 - 14 x 8 x 5 Alum. Vit.
Rec. 1/S 8 x 1½
Rec. 0/S 8 x 2

14 x 8 105 lbs.
5 x 8 (hole) 13.3
91.7 lbs.

Recess 1/S 1½" Thick
Recess 0/S 2" Thick
Equiv. to single recess 1/S8 x 3½ x 5*
9.2 deduct
Total 82.5 lbs.

*In figuring weights on intermediate thicknesses, proportion fractional thicknesses based on the 1" scale. Each recessed side may be calculated separately e g. 8 x 1½ x 5 and 8 x 2 x 5 or the two thicknesses can be added together as we have done making one deduction for an 8 x 3½ x 5 recess.

8 x 3½ = 12 8 lbs. ± (½ of 8x1) = 2.15 lbs or 14 95 lbs
5 x 3½ = 4.9 lbs. ± (½ of 5x) = .85 lbs. or 5.75 deduct
Total deduction 9.2 lbs.

NOTE: When using this weight chart to calculate the weight of an order for purposes of meeting the Freight Allowed Requirements, do *not* add the weight of packaging.

NOTE: A 3800Y A80R2R regulating wheel weighs 290 lbs.

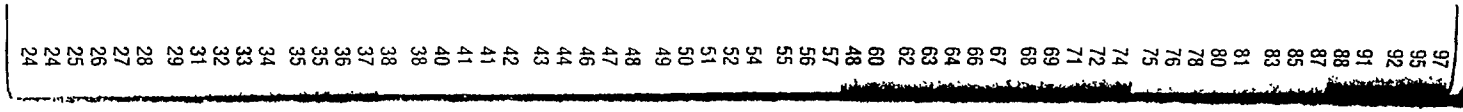
A 42 x 1 x 12 vitrified wheel weighs 92 lbs.

MIL 000067

Equivalent Hardness Numbers For Rockwell C Hardness Numbers

	Rockwell C-Scale Hardness No.	Diamond Pyramid Hardness No. Vickers	Brinnell Hardness No. 10-mm Ball, 3000-kg Load			Rockwell Hardness No.			Rockwell, Superficial Hardness No. Superficial Brale Penetrator			Shore Schleroscope Hardness No.
			Standard Ball	Hultgren Ball	Tungsten Carbide Ball	A-Scale 60-kg Load, Brale Penetrator	B-Scale 100-kg Load, 1/16 in. Dia. Ball	D-Scale 100-kg Load, Brale Penetrator	15-N Scale, 15-kg Load	30-N Scale, 30-kg Load	45-N Scale, 45-kg Load	
C8N	68	940	—	—	—	85.6	—	76.9	93.2	84.4	75.4	97
	67	900	—	—	—	85.0	—	76.1	92.9	83.6	74.2	95
	66	865	—	—	—	84.5	—	75.4	92.5	82.8	73.3	92
	65	832	—	—	739	83.9	—	74.5	92.2	81.9	72.0	91
	64	800	—	—	722	83.4	—	73.8	91.8	81.1	71.0	88
	63	772	—	—	705	82.8	—	73.0	91.4	80.1	69.9	87
9A	62	746	—	—	688	82.3	—	72.2	91.1	79.3	68.8	85
	61	720	—	—	670	81.8	—	71.5	90.7	78.4	67.7	83
	60	697	—	613	654	81.2	—	70.7	90.2	77.5	66.6	81
	59	674	—	559	634	80.7	—	69.9	89.8	76.6	65 5	80
	58	653	—	587	615	80.1	—	69.2	89 3	75.7	64.3	78
	57	633	—	575	595	79.6	—	68.5	88.9	74.8	63.2	76
	56	613	—	561	577	79.0	—	67.7	88.3	73.9	62.0	75
	55	595	—	546	560	78.5	—	66.9	87.9	73.0	60.9	74
29A	54	577	—	534	543	78.0	—	66.1	87.4	72.0	59.8	72
	53	560	—	519	525	77.4	—	65.4	86.9	71.2	58.6	71
	52	544	500	508	512	46.8	—	64.6	86.4	70.2	57.4	69
	51	528	487	494	496	76.3	—	63.8	85.9	69.4	56.1	68
	50	513	475	481	481	75.9	—	63.1	85.5	68.5	55.0	67
	49	498	464	469	469	75.2	—	62.1	85.0	67.6	53.8	66
	48	484	451	455	455	74.7	—	61.4	84.5	66.7	52.5	64
	47	471	442	443	443	74.1	—	60.8	83.9	65.8	51.4	63
	46	458	432	432	432	73.6	—	60.0	83.5	64.8	50.3	62
	45	446	421	421	421	73.1	—	59.2	83.0	64.0	49.0	60
	44	434	409	409	409	72.5	—	58.5	82.5	63.1	47.8	48
	43	423	400	400	400	72.0	—	57.7	82.0	62.2	46.7	57
	42	412	390	390	390	71.5	—	56.9	81.5	61.3	45.5	56
97A	41	402	381	381	381	70.9	—	56.2	80.9	60.4	44.3	55
	40	392	371	371	371	70.4	—	55.4	80.4	59.5	43.1	54
	39	382	362	362	362	69.9	—	54.6	79.9	58 6	41.9	52
	38	372	353	353	353	69.4	—	53.8	79.4	57.7	40 8	51
	37	363	344	344	344	68.9	—	53.1	78.8	56 8	39.6	50
	36	354	336	336	336	68.4	(109.0)	52.3	78.3	55.9	38 4	49
	35	345	327	327	327	67.9	(108.5)	51.5	77.7	55 0	37 2	48
	34	336	319	319	319	67.4	(108.0)	50.8	77.2	54.2	36.1	47
	33	327	311	311	311	66.8	(107.5)	50.0	76.6	53.3	34.9	46
	32	318	301	301	301	66.3	(107.0)	49.2	76.1	52.1	33.7	44
	31	310	294	294	294	56.8	(106.0)	48.4	75.6	51 3	32 5	43
	30	302	286	286	286	65.3	(105.5)	47.7	75.0	50.4	31.3	42
	29	294	279	279	279	64.7	(104.5)	47.0	74.5	49.5	30.1	41
	28	286	271	271	271	64.3	(104.0)	46.1	73.9	48.6	28 9	41
	27	279	264	264	264	63 8	(103.0)	45.2	73.3	47.7	27 8	40
	26	272	258	258	258	63.3	(102.5)	44.6	72.8	46 8	26 7	38
	25	266	253	153	153	62.8	(101.5)	43.8	72.2	45.9	25 5	38
	24	260	247	247	247	62.4	(100.5)	43.1	71.6	45.0	24.3	37
	23	254	243	243	243	62.0	100.0	42.1	71.0	44.0	23.1	36
	22	248	237	237	237	61.5	99.0	41.6	70.5	43 2	22.0	35
	21	243	231	231	231	61.0	98.5	40.9	69.9	42.3	20.7	35
2A	20	238	226	226	226	60.5	97.8	40.1	69.4	41.5	19 6	34
	(18)	230	1219	219	219	—	96.7	—	—	—	—	33
	(16)	222	212	212	212	—	95.5	—	—	—	—	32
	(14)	213	203	203	203	—	93.9	—	—	—	—	31
	(12)	204	194	194	194	—	92.3	—	—	—	—	29
	(10)	196	187	187	187	—	90.7	—	—	—	—	28
	(8)	188	179	179	179	—	89.5	—	—	—	—	27
	(6)	180	171	171	171	—	87.1	—	—	—	—	26
	(4)	173	165	165	165	—	85.5	—	—	—	—	25
	(2)	166	158	158	158	—	83.5	—	—	—	—	24
	(0)	160	152	152	152	—	81.7	—	—	—	—	24

Values in parentheses are beyond normal range and are given for information only.



Conversion Table — Wheel Speeds

Revolutions Per Minute For Various Diameters Of Abrasive Wheels To Give Surface Speed In Feed Per Minute As Indicated

Diameter of Wheel in Inches	Surface Speed in Feet per Minute																		Diameter of Wheel in Inches
	4,000	4,500	5,000	5,500	6,000	6,500	7,000	7,500	8,000	8,500	9,000	9,500	10,000	12,000	12,500	14,200	16,000	16,500	17,000	
	Revolutions per Minute				Revolutions per Minute			Revolutions per Minute			Revolutions per Minute					Revolutions per Minute				
1	15,279	17,189	19,099	21,008	22,918	24,828	26,737	28,647	30,558	32,467	34,377	36,287	38,197	45,837	47,746	54,240	61,115	63,025	64,935	1
1½	10,186	11,459	12,732	14,006	15,279	16,552	17,825	19,099	20,372	21,645	22,918	24,192	25,465	30,558	31,831	36,160	40,744	42,017	43,290	1½
2	7,639	8,594	9,549	10,504	11,459	12,414	13,369	14,324	15,279	16,234	17,189	18,144	19,099	22,918	23,873	27,120	30,558	31,513	32,468	2
2½	6,112	6,875	7,639	8,403	9,167	9,931	10,695	11,459	12,223	12,987	13,751	14,515	15,279	18,335	19,099	21,696	24,446	25,210	25,974	2½
3	5,093	5,730	6,366	7,003	7,639	8,276	8,913	9,549	10,186	10,823	11,459	12,096	12,732	15,279	15,915	18,080	20,372	21,008	21,645	3
3½	4,365	4,911	5,457	6,002	6,548	7,094	7,639	8,185	8,731	9,276	9,822	10,368	10,913	13,096	13,642	15,497	17,462	18,007	18,553	3½
4	3,820	4,297	4,775	5,252	5,730	6,207	6,685	7,162	7,640	8,117	8,584	9,072	9,549	11,459	11,937	13,560	15,279	15,756	16,234	4
5	3,056	3,438	3,820	4,202	4,584	4,966	5,348	5,730	6,112	6,494	6,875	7,257	7,639	9,167	9,549	10,848	12,223	12,605	12,987	5
6	2,546	2,865	3,183	3,501	3,820	4,138	4,465	4,775	5,093	5,411	5,730	6,048	6,366	7,639	7,958	9,040	10,186	10,504	10,823	6
7	2,183	2,456	2,728	3,001	3,274	3,547	3,820	4,093	4,365	4,638	4,911	5,184	5,457	6,548	6,821	7,749	8,731	9,004	9,276	7
8	1,910	2,149	2,387	2,626	2,865	3,104	3,342	3,581	3,820	4,058	4,297	4,536	4,775	5,730	5,968	6,780	7,639	7,878	8,117	8
9	1,699	1,910	2,122	2,334	2,546	2,759	2,971	3,183	3,395	3,608	3,820	4,032	4,244	5,093	5,305	6,027	6,791	7,003	7,215	9
10	1,528	1,719	1,910	2,101	2,292	2,483	2,674	2,865	3,056	3,247	3,438	3,629	3,820	4,584	4,775	5,424	6,112	6,303	6,494	10
12	1,273	1,432	1,592	1,751	1,910	2,069	2,228	2,387	2,546	2,706	2,865	3,024	3,180	3,820	3,979	4,520	5,093	5,252	5,411	12
14	1,091	1,229	1,364	1,501	1,637	1,773	1,910	2,046	2,183	2,319	2,456	2,592	2,728	3,274	3,410	3,874	4,365	4,502	4,638	14
16	955	1,074	1,194	1,313	1,432	1,552	1,671	1,790	1,910	2,029	2,149	2,268	2,387	2,865	2,984	3,390	3,820	3,939	4,058	16
18	849	955	1,061	1,167	1,273	1,379	1,485	1,592	1,698	1,804	1,910	2,016	2,122	2,546	2,653	3,013	3,395	3,501	3,608	18
20	764	859	955	1,050	1,146	1,241	1,337	1,432	1,528	1,623	1,719	1,814	1,910	2,292	2,387	2,712	3,056	3,151	3,247	20
22	694	781	868	955	1,042	1,129	1,215	1,302	1,389	1,476	1,563	1,649	1,736	2,083	2,170	2,465	2,778	2,865	2,952	22
24	637	716	796	875	955	1,035	1,114	1,194	1,273	1,353	1,432	1,512	1,592	1,910	1,989	2,260	2,546	2,625	2,706	24
26	588	661	735	808	881	955	1,028	1,102	1,175	1,249	1,322	1,396	1,469	1,763	1,836	2,086	2,351	2,424	2,498	26
28	546	614	682	750	819	887	955	1,023	1,091	1,160	1,228	1,290	1,364	1,637	1,705	1,937	2,183	2,251	2,319	28
30	509	573	637	700	764	828	891	955	1,019	1,082	1,146	1,210	1,273	1,528	1,592	1,808	2,037	2,101	2,165	30
32	477	537	597	657	716	776	836	895	955	1,015	1,074	1,134	1,194	1,432	1,492	1,695	1,910	1,970	2,029	32
34	449	506	562	618	674	780	786	843	899	955	1,011	1,067	1,123	1,348	1,404	1,595	1,798	1,854	1,910	34
36	424	477	531	584	637	690	743	796	849	902	955	1,008	1,061	1,273	1,326	1,507	1,698	1,751	1,804	36
38	402	452	503	553	603	653	704	754	804	854	905	955	1,005	1,206	1,256	1,427	1,608	1,659	1,709	38
40	382	430	477	525	573	621	668	716	764	812	859	907	956	1,146	1,194	1,356	1,528	1,576	1,623	40
42	364	409	455	500	546	591	637	682	728	773	819	864	909	1,091	1,137	1,291	1,455	1,500	1,546	42
44	347	391	434	477	521	564	608	651	694	738	781	825	868	1,042	1,085	1,233	1,389	1,432	1,476	44
46	332	374	415	457	498	540	581	623	664	706	747	789	830	996	1,038	1,179	1,329	1,370	1,412	46
48	318	358	398	438	477	517	557	597	637	676	716	756	796	955	995	1,130	1,273	1,313	1,353	48
53	288	324	360	396	432	468	504	540	577	613	649	685	721	865	901	1,023	1,153	1,189	1,225	53
60	255	286	318	350	382	414	446	477	509	541	573	605	637	764	796	904	1,019	1,050	1,082	60
72	212	239	265	292	318	345	371	398	424	451	477	504	531	637	663	753	849	875	902	72

Note "Centrifugal Force," which is the force that tends to rupture a given wheel when overspeeding, increases as the square of the velocity of that wheel. For example, the centrifugal force in a wheel running at 5,500 surface feet per minute is 49 per cent greater than in the same wheel running at 4,500 surface feet per minute, although the speed is actually only 22 per cent greater.

The grinding wheel, when carefully and correctly used, is a safe cutting tool. But if misused or abused, it does have a very dangerous potential. When we know that the rim of a wheel running at 6500 surface feet per minute is traveling at a rate of over 70 miles per hour, we can understand how dangerous any grinding wheel can be if it is broken by mishandling or misuse.

Recommendations and rules to maintain the safety of grinding wheels are listed in the booklet "Safety Requirements for the Use, Care and Protection of Abrasive Wheels." This summarizes knowledge gained from decades of research and from literally thousands of man-years of practical experience with abrasive tools. It is by far the most comprehensive and authoritative document on grinding safety in the English language. This booklet is highly recommended reading for people involved in the mounting or use of grinding wheels, segments, or mounted points. The American National Standards Institute (ANSI) standard B7.1 will be referred to here as the safety code.

One requirement of the safety code is a prooftest: all sizeable grinding wheels must be overspeed tested by the wheel manufacturer before shipment. Typically, this test stresses each wheel to 2-1/4 times the rotational stress of its maximum usage speed. The test destroys any wheel of substandard strength, so it ensures that all surviving wheels are structurally sound. Hence, a precision wheel is perfectly safe to use immediately after its overspeed test. However, it can become very unsafe if it is cracked, chipped or gouged after that test. So there is good reason to say that grinding wheels don't break, they are broken.

Listed below are some general precautions that should be observed in the use of abrasive wheels. More detailed information is in the safety code (ANSI B7.1 - latest edition) available from: The Grinding Wheel Institute, 712 Lakewood Center, North Cleveland, Ohio 44107; American National Standards Institute Inc., 1430 Broadway, New York, NY 10018; or any grinding wheel manufacturer including Products Division/Cincinnati Milacron Marketing Company, 4701 Marburg Avenue, Cincinnati, Ohio 45209.

Use the Right Wheel

If the wheel was designed for grinding on its periphery, do not grind on its side. If it was designed for grinding on its side (Type 2 or Type 6 wheels, for instance) do not grind on the periphery.

Maximum Speed

The maximum operating speed (max RPM) is marked on each wheel, its blotter, or (for small wheels) its container. This number and the outer diameter D1 (in inches) of the new wheel establishes its maximum surface feet per minute (max sfpm) by the formula:

max sfpm = 3.1416 D1 (max RPM)/12

On the adjacent page is a table, based on this formula, for converting wheel diameter and RPM to spfm and vice versa. The max spfm of the new wheel sets the safe usage limit of that wheel. That is, as the wheel OD is worn down, its RPM may be increased as long as that max sfpm is never exceeded. To maintain the new-wheel sfpm as the OD wears, the following formula may be used:

max RPM 2 = D1 over D2 (max RPM 1)

where the numbers 1 and 2 refer to the original wheel and to the worn wheel respectively.

Standard and Special Speeds

Mismatching wheel and machine speeds can be dangerous. Recognizing this, wheel and machine manufacturers have agreed over the years on certain standard speeds that both groups can design to. Table 24 of the safety code defines these standard speeds. Although the typical wheel user will have little use for this complex table, he should be aware that it may affect the safety of his operations.

A sure and direct way for the wheel user to avoid mismatching is to routinely specify the actual speed of his machine on all orders for grinding wheels. This practice is strongly recommended by Cincinnati Milacron. In the absence of a speed call-out on an order, Milacron will supply a standard-speed product. The max RPM marking of the wheel alerts the user not to use the wheel if the machine speed exceeds that standard speed. If such a potential mismatch occurs, return the wheel along with a notation of the actual machine speed.

To avoid speed mismatches, section 7 of the safety code recommends that speed checks be made periodically on all grinding machines. Specific times to do this are cited there by machine type.

A "special" speed is, by definition, any speed that exceeds the appropriate standard speed listed in Table 20 of the safety code. To maintain safety at these higher speeds, section 8 of the code places special requirements on the machine builder, the wheel manufacturer, and the wheel user. The chief responsibilities of the user are to make certain that all guarding and other safety devices supplied with the machine are used and maintained in good working order, and that all safety precautions specified by the machine manufacturer are followed.

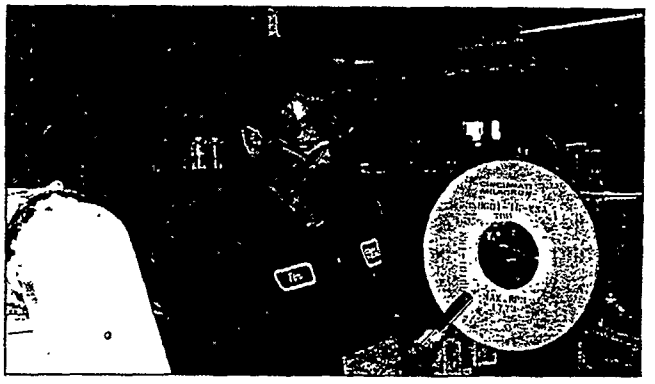
Cincinnati Milacron strongly recommends that users do not attempt to increase the wheel speed of any grinder beyond its original design value, nor alter its original guarding. Any intended modification of other safety-related equipment should first be discussed with and approved by the machine manufacturer.

Inspection, Handling and Storage

All grinding wheels can be broken or damaged and should be handled as fragile items. The as-manufactured strength of wheels depends upon their bond type, grit size, grade, shape and size. However, careless storage, handling, transport, mounting, or usage can degrade this original strength by breaking or weakening the bonding material that holds the wheel together.

Inspection. Wheels should be visually inspected for chips, cracks, or other indications of rough handling. This should be done when they are first removed from their shipping container, or as soon as damage to the container itself is noticed. Immediately discard or return to the manufacturer any wheel showing such damage. It is important that these wheels be segregated so they cannot possibly be used.

Handling, In-Plant Transport. All wheels are impact-sensitive and should be protected from sudden shocks. They should not be moved or supported by metal devices, e.g. lift truck forks or hoist hooks, unless the metal contact areas are covered by resilient material. Any wheel that is dropped should be considered damaged. Do not roll wheels on shop floors — cover the path with clean, staple-free cardboard. Do not lay wheels directly on any metal, brick, or similar hard, rigid surface.



Storage. Store wheels on resilient material and only in places that are dry and free from extremes of temperature and humidity. Water-soaking can gradually weaken resinoid wheels; telephone the manufacturer for advice if this happens. Both resinoid and vitrified wheels should be considered unsafe if they are wetted and then subjected to freezing temperatures. A ring test should not be relied upon to detect the widely distributed damage due to freezing a damp wheel.

MIL 000071

Mounting Grinding Wheels — General

History proves that grinding wheel breakage can result from many causes. However, for precision grinding wheels, one factor stands out. Careful analysis of many precision wheels broken during use shows that improper mounting is involved in more than 50% of all breakages. For this reason, each of the several methods of mounting precision wheels are individually discussed in the following sections.

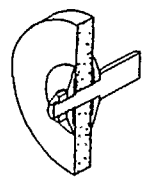
In all cases, metal machine components must not press directly on abrasive surfaces. A blotter is to be used between the abrasive and any type of clamping flange or device. Similarly, when a spacer is used beside or between wheels, a blotter must be placed between each spacer and its mating abrasive surface. The spacer's clamping surface(s) must conform to the same geometric requirements that the safety code places on that machine's flanges. For example, for multi-screw flanged machines, any spacer used adjacent to a grinding wheel should be relieved near the bore, be the same OD as the flanges, and meet their flatness requirement.

To detect possible damage during in-plant storage, handling, or transport it is important that all wheels be thoroughly inspected immediately before mounting and at the mounting site. This means they should be inspected visually all over, despite any earlier visual inspections, and ring tested. Exceptions are segments, plate-mounted and nut-inserted wheels, mounted points, and some small (e.g. less than 4") wheels; these are difficult or impossible to ring test.

To ring test a wheel that is small enough to hold in one hand, the wheel should be suspended from the hole on a finger. If the wheel is too heavy, it can be supported by a hoist. If it is not possible to suspend the wheel free in the air, it can be rung while in a vertical position on a clean hard floor. the wheel should be dry and free from sawdust or other packing material.

Tap the side of the wheel gently with a nonmetallic instrument (the handle of a screwdriver or a wooden hammer) about 45 degrees to one side of the vertical centerline and 1 or 2 inches inboard from the OD. Then rotate the wheel about 45 degrees in its suspension and tap again. A good vitrified wheel will have a clear metallic ring. A resinoid wheel may not give a clear ring and must be visually examined for cracks. Large, thick wheels may be ring tested by striking the wheel on the periphery rather than the wheel side.

If there is any reason whatsoever to suspect that a wheel has been damaged, do not mount it. But also do not use the ring test to "disprove" the suspected damage. The ring test should be used to detect unknown cracks but not to discount other evidence of damage — it is not infallible. When damage is suspected, the only safe options are to destroy the wheel beyond further use, or return it to its manufacturer for re-inspection.



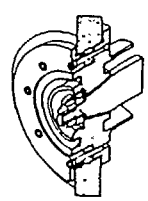
Arbor-Mounted. New, clean blotters should be used on both sides of the wheel. They assure even pressure on the flanges around the arbor hole. Be careful not to wedge the blotter within the wheel bore.

Flanges and spacers should be of equal diameter (inspect with a straightedge), flat and free of nicks. Nicks and other protrusions should be carefully removed with file and stone. The diameter of the flanges should be at least one-third the diameter of the wheel. See the safety code for exceptions, flange dimensions and spindle diameters.

The wheel should slide easily onto the arbor. If it doesn't use another wheel; do not force the wheel or try to use a larger, wide or narrower wheel than the size for which the machine was designed.

If the wheel has the word "Top" or mount up on it, rotate the wheel so that "Top" is at the 12 o'clock position when the clamping nut is tightened. This will keep the hole clearance on the bottom, as it was when the wheel was manufactured. This provides better concentricity and balance, and means less initial truing.

The nut should be uniformly tightened only enough to keep the wheel from slipping; do not use a hammer because over-tightening can warp the flanges, putting high bore stresses in the wheel. The nut should tighten in the opposite direction from wheel rotation!



Collet and Flange. Follow all general instructions (see Mounting Grinding Wheels — General above) and those for Arbor Mounted (above) down to tightening the nut.

First tighten the screws with slight finger pressure only. then tighten to 15 ft. lbs. with a torque wrench. Follow a criss-cross sequence of tightening the screws. Repeat this tightening procedure at least three (3) times or more until all screws are pulled to the prescribed ft. lb. figure. Wider wheels may require more; the torque recommended by the machine manufacturer should be followed if it is other than 15 ft. lbs.

Excessive tightening may spring the flange and collet. Warpage will reduce the contact area between the flanges and the wheel, and produce dangerously high bore stresses.

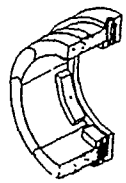
Additional precautions are necessary for mounting large wheels on multi-screw flanges. These are covered in the next section.

Large Wheels, Including Centerless. No large, heavy wheel should be mounted manually. The lifting effort required precludes accuracy of alignment and smooth mating of the wheel bore and spindle. Both of these are essential to maintain the safety of the wheel. The initial contact between the spindle and the bore is likely to be jerky and can cause chipping or other damage to the wheel. Some cocking is almost unavoidable. A power lift should be used to avoid these problems.

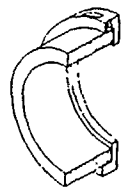
Some large centerless grinders require removal of the spindle from the machine to change wheels. The machine manufacturer usually provides special fixtures to do this job. Power lifts for these fixtures are recommended. Chainfalls do not usually provide small enough steps of vertical movement to allow accurate alignment, so cocking of the spindle is likely and this endangers the wheel bore. Also, both spindle and wheel bore should be horizontal during mating. This allows the person mounting the wheel to feel any resistance to entry of the spindle into the wheel bore, so he can avoid forcing or cocking. He does not have these factors under his control if mounting is done vertically — the weight above the spindle or wheel is usually enough to chip or crack the wheel, and this is likely unless alignment is absolutely perfect.

Threaded hole wheels. Check that the direction of rotation will tighten the wheel on the threaded arbor and not loosen it. Mounting rotation should be opposite to spindle rotation. Be sure that the blotter is smooth and on the wheel. The threads of the arbor, or of the mounting bolts in the case of nut inserted discs, should not quite bottom in the threaded hole. Be certain that the back flange is not recessed or relieved (threaded hole wheels only).

Limitations. Threaded hole cup wheel mounting should not be used with wheels larger than 6" diameter. The maximum volume of cones and plugs should not be greater than 35 cu. in. (Example: a 3" OD by 5" long type 18 wheel. $3.1416 \times R^2 (1\text{-}5^2) H (5") = 35.3$).



Segments. The many segment chucks available have a variety of clamping methods. Detailed instructions can be obtained from the chuck manufacturer. Be sure clamping surfaces are clean and flat.



Cylinders. Before mounting the wheel, suspend it and tap it with the end of a screwdriver or a wooden hammer. Resinoid wheels do not give the clear ring of a vitrified wheel, so they must be carefully inspected visually.

Screw clamps should be tightened only enough to keep the wheel from slipping in the chuck. Vellumoid strips should be placed between the wheel and the clamps to serve as blotter cushions. Be sure the chuck is completely clean of old blotter and swarf before mounting a new wheel.

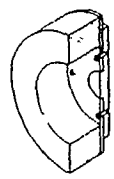
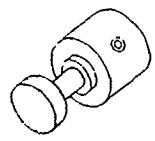


Plate mounted wheels. Plates should be checked with a straightedge for flatness and wheel plate should be smooth and free of nicks. Mounting screws should not bottom in the threaded holes.



Mounted wheels. The length of overhang of the wheel beyond the chuck has a bearing on the maximum safe speed. The safety code or the Grinding Wheel Institute's "Mounted Wheels - Safe and Efficient Operation" - latest edition, should be consulted to be certain maximum safe speed is not exceeded.

MIL 000073

Mounting Flanges — ANSI B7.1

All abrasive wheels shall be mounted between flanges which shall not be less than one-third the diameter of the wheel. Both flanges, of any type, between which a wheel is mounted, shall be of the same diameter and have equal bearing surface.

Guards

Always use a guard. See that it is properly mounted and that all screws are in place and tight.

If the wheel should be broken because of accident or neglect, make sure any damage to the guard is repaired or the guard is replaced. A damaged guard is not much protection. All guards should conform to Section 4 of the safety code (ANSI B7.1).

Workrest

Keep the workrest on a bench or stand grinder in repair and properly adjusted to no more than 1/8" away from the wheel.

Starting the Wheel

Stand to one side whenever you start a wheel. Allow new wheels to run at least one minute before grinding.

VRWE SUPER CIMFORM

Aluminum Oxide Vitrified Wheels

16,000 SFPM Operation

The following SUPER CIMFORM wheel grades are available for 16,000 sfpm operation under the following conditions:

1. Grades as shown in the table below only.
2. 20" to 24" in diameter, 2½" or less in thickness, 12" or smaller ID. (12.050 also)
3. For use only on machines approved by machine manufacturer.

Grit Size	Available Grade			
	Hard Center*		Non-hard Center	
	4 Structure	6 Structure	4 Structure	6 Structure
80 90	K-S K-Q	K-M K-M		
100 120	K,L	K,L	M-Q J-Q	M K-M
150 180 220			J-N J-N J-N	

**Wheel specifications must shown "VE0685 suffix code. Example: 2A80-K6-VE0685*

Wheel Discard Size — ANSI B7.1

The usable portion of an abrasive wheel shall be considered to be that portion which extends beyond the mounting flanges. A wheel shall not be worn down to a size which would allow the mounting flange assembly to contact the workpiece or workpiece holding fixture.

Safety Glasses

Protect your eyes when grinding. You can lose your safety glasses and get another pair but you will lose your eyesight only once.

Grinding Fluid

Turn on the grinding fluid only after the wheel has reached speed, and turn off the fluid before turning off the wheel. Running the fluid on a stopped wheel will create a heavy side and out-of-balance condition.

VFME CIMFORM

Aluminum Oxide Vitrified Wheels

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Grit Size	Available Grade			
	Hard Center*		Non-hard Center	
	4 Structure	6 Structure	4 Structure	6 Structure
80 90	K-N K, L	K-N K-M	O-S M-S	
100 120		K,L K,L	M-S J-S	M M
150 180 220			J-S J-R J-R	

**Wheel specifications must shown "VE0615 suffix code. Example: 2A80-K6-VE0615*

NOTE: The wheel size restrictions do not apply to non-hard center wheels. However, the I.D. must not exceed 60% of the wheel O.D. and all orders should show the operating speed.

Grinding Wheel Safety Guide

Grinding wheels improperly used are dangerous, but grinding is a safe operation if the few basic rules listed below are followed. These rules are based on material contained in the ANSI B7.1 Safety Requirements for the "Use, Care and Protection of Abrasive Wheels."

Storage

Suitable racks, cradles and drawers should be provided to store the various types of wheels used. The sketches indicate a typical rack storing a range of wheels.

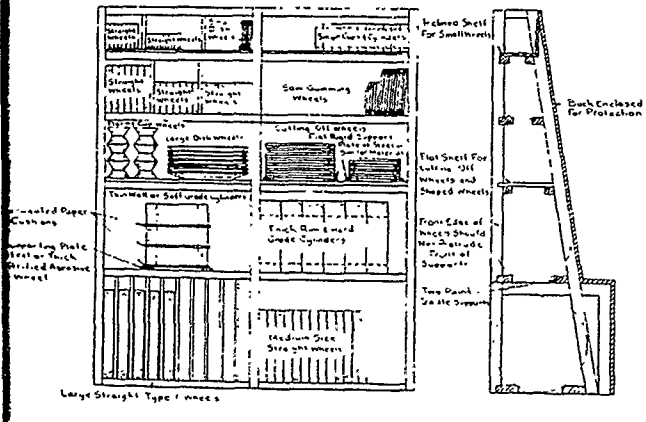
Do:

1. Store wheels correctly supported.
2. Stack thin wheels flat.
3. Ensure storage in dry conditions.

Do Not:

1. Store in damp or humid conditions.
2. Subject wheels to dramatic change in temperature.
3. Subject wheels to temperatures at or approaching freezing.

Typical Storage Rack



Mounting

Correct mounting procedures are essential to the efficient and safe operation of the wheel. It is important that personnel performing the function are fully competent.

Do:

1. Visually inspect all wheels before mounting for possible damage.
2. Check machine speed against the established maximum safe operating speed marked on the wheel.
3. "Ring" wheel to determine if it is free from cracks.
4. Use one clean blotter on each side of wheel.
5. Check mounting flanges for equal and correct diameter) generally 1/3 diameter of wheel).
6. Tighten multi-screw flanges uniformly to the machine manufacturer's suggested torque with a torque wrench.

Do Not:

1. Mount a cracked wheel or one that has been dropped or has become damaged.
2. Use wheels whose maximum r.p.m. is less than the r.p.m. of the machine spindle.
3. Force a wheel onto the machine or alter the size of the mounting hole - if the wheel doesn't fit the machine, get one that will.
4. Use flanges of unequal diameter or relief, nor those which are not clean, flat or free of burrs.
5. Over-tighten flange retaining nuts.

Use

Given the correct wheel, mounted in accordance with approved procedure, safe operation depends largely on the treatment to which the wheel is subjected during use.

Do:

1. Ensure that guards and workrests are properly adjusted and secure before starting machine.
2. Always use a safety guard covering at least one-half the grinding wheel.
3. Allow a newly mounted wheel to run at operating speed with guard in place at least one minute before starting to dress or grind.
4. Always wear protective glasses or some type of eye protection when grinding.
5. Always dress or make grinding contact gently.
6. Re-dress the wheel when necessary.
7. Turn off the coolant before stopping the wheel to avoid creating an out-of-balance condition.

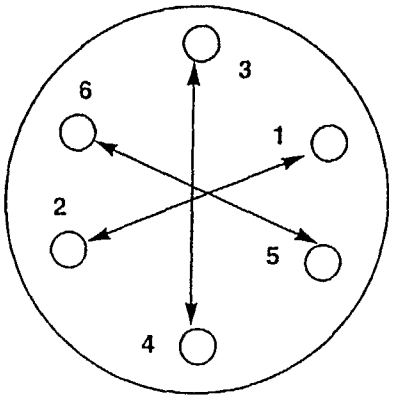
Do Not:

1. Ever exceed the maximum operating speed established for the wheel.
2. Start the machine until the guard is in place.
3. Stand directly in front of the wheel when the machine is started.
4. Jam the work into the wheel, nor use excessive pressure or infeed.
5. Force grinding so that the motor slows noticeably or the work gets hot.
6. Grind on the side of the wheel (see ANSI B7.1 for exception).
7. Allow stationary wheels to rest in fluids.
8. Apply pressure to wheels to stop them.
9. Continuously use glazed wheels without dressing.
10. Use wheels for purposes other than those for which they are designed.

MIL 000075

Proper Wheel Mounting Techniques and Appropriate Torque Pressures

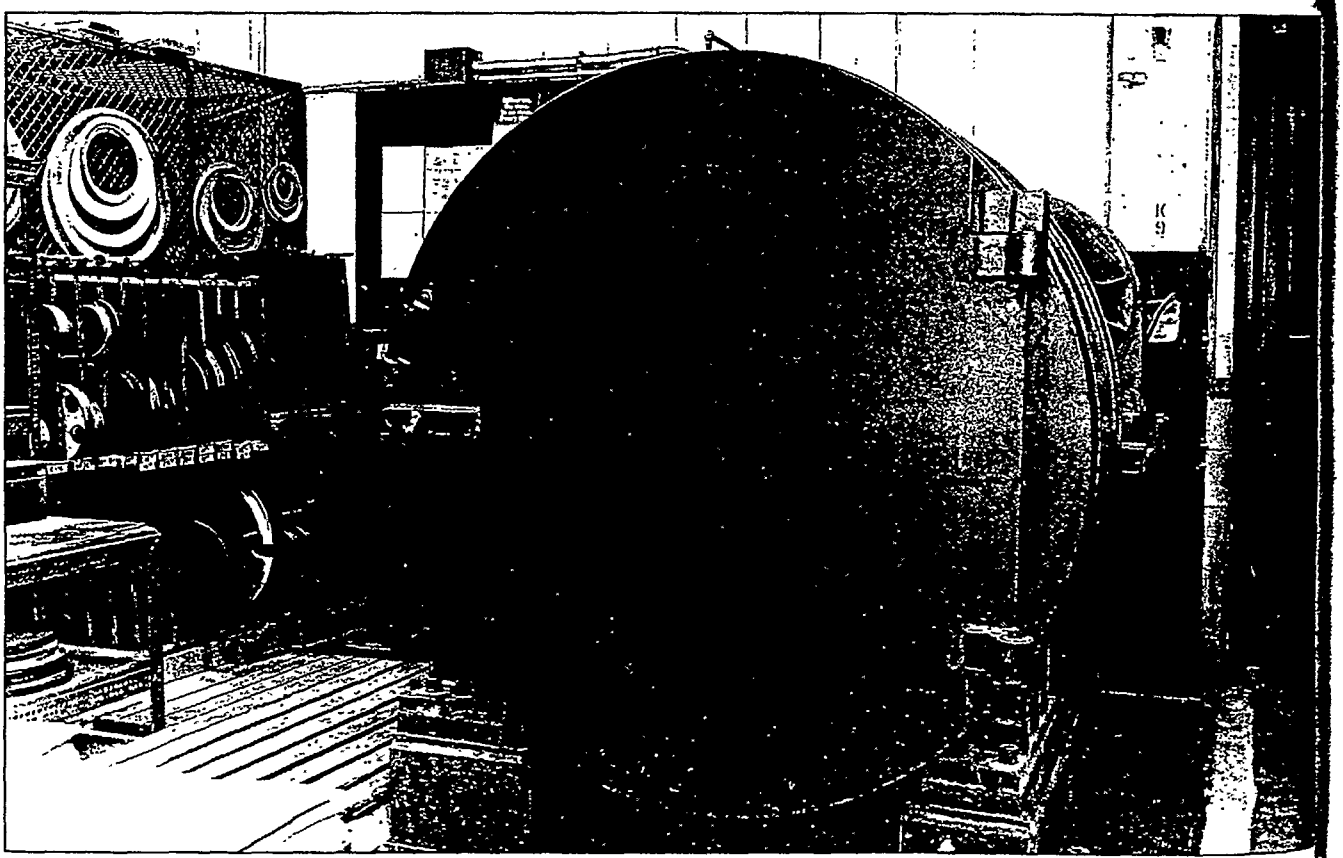
Tightening Sequence



Width of Wheel	Torque Pressure
1″	15-20
3″	25-30
5″	30-35
10″	40-45
20″	45-50

Check torque pressure after running 3-4 shifts.

Inquire about Cincinnati's latest VHS video — Safe Use and Storage o Grinding Wheels.



This is one of the many inspection stations in Cincinnati's plant. This machine can spin test wheels up to 42" diameter up to 5000 RPM. This machine is constructed of 1¼ plate steel.

MIL 000076

Pub. No. PG-305-6

CINCINNATI MILACRON
GRINDING WHEELS

Date of Breakage

BROKEN WHEEL REPORT

Note: Because the careful handling and safe use of CINCINNATI MILACRON Grinding Wheels are beyond the control of Cincinnati Milacron, the company assumes no responsibility for damaged or broken wheels.

Instructions

1. Submit for all wheels broken in operation on a machine.
2. Answer all questions. If you cannot get an answer, please so indicate. Use extra pages if necessary.
3. When the question is followed by the symbol (A), identify source of information if other than your own observation.

Customer:

Address:

Wheel Size & Type: Purchase Order Number:

Wheel Spec. (grading): Our M (mfg) Number:

Whom did we bill and when? Date Wheel Shipped from Cincinnati:

Date Broken: _____ Time of Day: _____ AM; _____ PM

Was anyone injured or sent home? Yes _____; No _____. If yes, describe on page 4 of this report.

Max. RPM marked on wheel or blotter: _____ RPM

Damaged Wheel: Ship all pieces of damaged wheels, bushings, inserted nuts, blotters, etc. to Cincinnati Milacron, c/o Abrasive Product Manager. Damaged work parts, collets, centerless blades, and any other items involved in accident can also be helpful. All such material will be retained for a period of 5 years whenever injury was sustained in the accident.

Shipped back via: Waybill No.: Date

MIL 000077

GRINDING MACHINE:

Manufacturer: Size & Type: Serial No. _____

Customer No. _____

Condition of machine & bearings (A): Good _____; Fair _____; Poor _____.

Equipped with movable work rest? Yes _____; No _____.

If so, how far was it from wheel just before accident? _____in.

Can the operator vary the spindle R.P.M.? Yes _____; No _____.

Spindle R.P.M. at time of accident (by tachometer):

Were any pieces of blotter from previous wheels or any other foreign material adhering to flanges or spindle?

Yes _____; No _____. If yes, describe briefly:

Number of prior breakages: this machine _____; similar machines nearby _____.

MOUNTING:

Spindle and flange pilots — any burrs or high-pressure points? Yes _____; No _____.

If yes, estimate of max. height: _____in.

Diameter of: spindle _____in.; loose-flange pilot _____in.

Flanges: Was spacer used between flange & wheel? Yes _____; No _____.

If so, show data for spacer(s) rather than flange(s).

Dimensions (measure with steel ruler):

	A (in.)	B (in.)
Loose Flange:	_____	_____
Fixed Flange:	_____	_____

Blotter bearing surfaces — measure out-of-flatness (e.g. with feeler gauges and straight edge); note max. value on appropriate line:

	Loose Flange	Fixed Flange
Concave?	_____ in.	_____ in.
Convex?	_____ in.	_____ in.
Wavy?	_____ in.	_____ in.

Nicked? Gouged? Corroded? (Circle appropriate items.)

How tight were flange screws? (A) (Check with torque wrench on similar machine nearby.)

Mount loose flange on bare spindle (collet), using all original screws. Do flange faces pull in to less than width of this wheel? Yes _____; No _____

Do one or more screws 'bottom' before this critical spacing is reached? Yes _____; No _____.

If yes, how many? _____.

Was wheel run before mounting? (A): Yes _____; No _____.

MIL 000078

MOUNTING (cont'd)

Thread condition, mounting nut or flange screws: Good _____; Poor _____.

Blotters used? Yes _____; No _____. If so, mark blotter nearer driven end of spindle (fixed flange) and return both blotters with wheel.

Hours wheel had been rotating since: Mounting _____; Last Start-up _____.

Was wheel ever re-mounted? Yes _____; No _____. How many times? _____.

GRINDING OPERATION:

Sketch of part (show nominal dimensions, surfaces ground, & stock removal: Part Name & Material:

Cutting fluid (circle appropriate one): Water soluble; Oil; Dry.

Anything jammed between wheel and machine? (A) (Look for gouged part or tools in machine base or nearby scrap container; send to Cincinnati.)

Wheel open to outside damage while running or while stopped, by cranes, trucks etc.? (A) Yes _____; No _____.

Events leading up to breakage — comments by operator, supervisor, witnesses, etc.

WHEEL STORAGE AND HANDLING:

How are wheels inspected on receipt? (A)

How are wheels stored? (A)

How are wheels inspected before mounting? (A)

Was this one? (A)

Are wheels rolled on floor at any time? Yes _____; No _____.

Any other abusive handling? Yes _____; No _____. If so describe

MIL 000079

REPORT OF INJURY: (If no injury or lost personnel time, so note on Page 1 and omit the following questions. However, sign report at bottom of this page.)

Injured person's: Name:

Address:

Age:

Length of service, this job: _____ years.

Was the person wearing: goggles; safety glasses; face shield; leather apron; safety shoes?

(Circle items pertinent to this injury.)

Wheel guard in place: Before accident? Yes _____; No _____.

After accident? Yes _____; No _____.

If not, briefly describe.

Was guard adjustable for wheel wear? Yes _____; No _____. If so, how far was movable member from wheel OD just prior to accident? _____in. (Look for fresh scrapes next to clamping screw or nut, re-position, and measure.)

Name of employer's Workmen's Compensation Insurance carrier:

Name of doctor or nurse attending:

Address:

Has injured person returned to work? Yes _____; No _____.

How much lost time occurred? _____ Is expected to occur? _____.

If hospitalized, name and address of hospital:

Extent of injury, and from whom did you get information.

Witnesses: Name Address

1.

2.

3.

Signed _____

Report date: _____

MIL 000080

3 CIMCOOL®
Cutting and Grinding Fluids

CIMCOOL® metalworking fluids were developed to meet your application requirements, however demanding. The CIMCOOL® line consists of water-soluble synthetic, semi-synthetic and premium soluble oil products.

Benefits include:

- excellent corrosion control
- high degree of lubricity for prolonged tool life
- pleasant to use
- greater stability in hard water
- lower misting properties
- recyclable
- easy disposal

CIMTECH® Synthetic Metalworking Fluids

Ideal for light- to heavy-duty operations, CIMTECH is extremely clean and has excellent corrosion control and low misting characteristics.

Applications include:

- automotive
- bearing
- farm implement
- construction equipment
- carbide grinding
- glass and mirror grinding

CIMSTAR® Semi-Synthetic Metalworking Fluids

CIMSTAR brings users the best of both worlds: the benefits of oil content and the advantages of synthetic-type fluids. It is well suited for individual machine and central system applications.

CIMPERIAL® Soluble Oil Metalworking Fluids

CIMPERIAL products are designed for moderate- to heavy-duty cutting and grinding operations. Known for their excellent rancidity control, many CIMPERIAL products also contain extreme pressure lubricant packages for enhanced machining and grinding performance in difficult applications.

CIMCOOL® Specialty Products

Designed to complement CIMCOOL® metalworking fluids, these specialty products can help keep your operations running smoothly:

- CIMCLEAN® Industrial Cleaners
- CIMTAP® Tapping Compounds
- CIMGUARD® Corrosion Preventives
- CENTERSAVER® Waterproof Grease

CIMCOOL® ENVIROTREAT® Ultrafiltration System

A wastewater treatment system designed to treat oily wastewater for sewer discharge, Milacron's ENVIROTREAT Ultrafiltration System can reduce the volume of oily wastewater by 90%. The unit processes fluid at a rate of 300 gallons per day.

100 Gallon CIMCOOL® Recovery Unit

The fast and efficient CIMCOOL® Recovery Unit (CRU) is a portable industrial liquid vacuum cleaner designed to quickly clean out individual machine fluid reservoirs. The unique caster design enables the CRU to pivot for easy maneuvering in small areas and narrow shop aisles.

CIMCOOL® Oil Wheel

The CIMCOOL® Oil Wheel removes tramp oil from individual machine reservoirs.

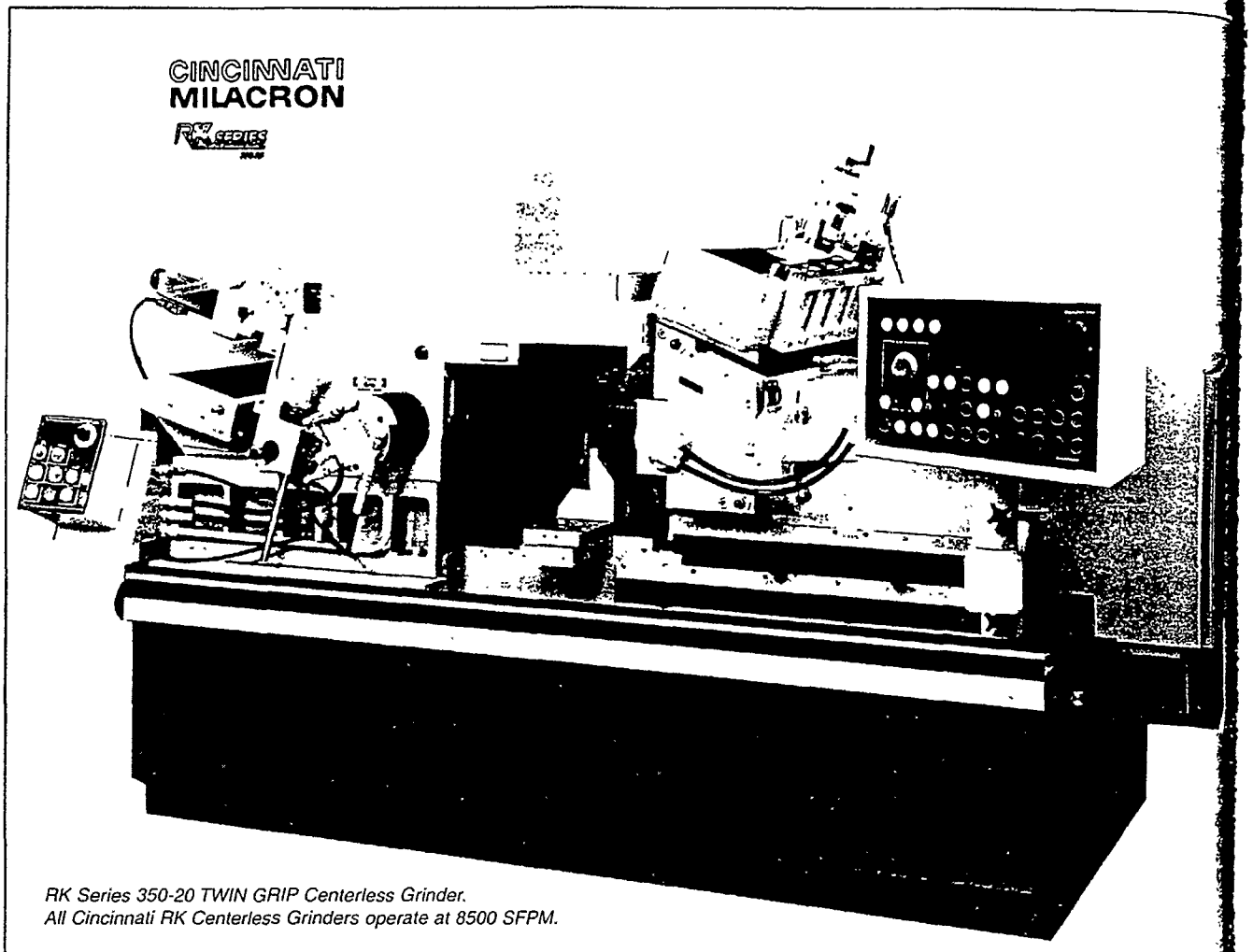
CIMCOOL® Mixmaster Proportioners

Mixmaster Proportioners, available in either drum or reservoir models, are designed to mix the right amount of fluid concentrate with water.

MATERIAL OPERATION	Cast Iron	Carbon Steel	Alloy Steel	Aluminum Copper	Exotic Materials
Surface	CIMTECH 100	CIMTECH 100	CIMTECH 100	Not Applicable	CIMTECH 100 CIMTECH 410
Centertype/ Microcentric	CIMTECH 410 CIMSTAR 40 CIMSTAR 60/60LF	CIMTECH 410 CIMSTAR 40 CIMSTAR 60/60LF	CIMTECH 410 CIMSTAR 60/60LF CIMPERIAL 1011	CIMSTAR 40 CIMSTAR 60/60LF CIMPERIAL 1011	CIMTECH 410 CIMSTAR 60/60LF CIMPERIAL 1011
Centerless	CIMTECH 410 CIMSTAR QUAL STAR/LF	CIMTECH 410 CIMSTAR QUAL STAR/LF	CIMTECH 410 CIMSTAR 60/60LF	CIMSTAR 40 CIMSTAR 60/60LF	CIMPERIAL 1010 CIMPERIAL 1011
Internal	CIMTECH 100 CIMSTAR 40	CIMTECH 410 CIMSTAR QUAL STAR/LF	CIMTECH 410 CIMSTAR 60/60LF	CIMSTAR 40 CIMPERIAL 1011	CIMSTAR 60/60LF CIMPERIAL1011
Form	CIMTECH 410 CIMSTAR 60/60LF CIMPERIAL 1011	CIMSTAR 60/60LF CIMPERIAL 1011 CIMPERIAL 20	CIMSTAR 60/60LF CIMPERIAL 1011 CIMPERIAL 20	CIMPERIAL 1010 CIMPERIAL 1011	CIMPERIAL 1010 CIMPERIAL 1011
Thread/ Flute	CIMTECH 410 CIMSTAR 60/60LF	CIMTECH 410 CIMPERIAL 1011	CIMTECH 410 CIMPERIAL 1011	CIMPERIAL 1011	CIMPERIAL 1010 CIMPERIAL 1011
Tool Room/ General Purpose	CIMSTAR 40 CIMSTAR 60/60LF CIMPERIAL 1011	CIMSTAR 40 CIMSTAR 60/60LF CIMPERIAL 1011	CIMSTAR QUAL STAR/LF CIMSTAR 60/60LF CIMPERIAL 1011	CIMSTAR QUAL STAR/LF CIMSTAR 60/60LF CIMPERIAL 1011	CIMSTAR 60/60LF CIMPERIAL 1010 CIMPERIAL 1011

MIL 000081

4 Centerless Grinding



RK Series 350-20 TWIN GRIP Centerless Grinder.
All Cincinnati RK Centerless Grinders operate at 8500 SFPM.

RK Centerless Grinder Brief Specifications

Grinding Wheel

Diameter maximum/minimum ..... 24/17" (609/431 mm)
Hole size ..... 12" (304 mm)

Regulating Wheel

Diameter maximum/minimum ..... 14/11" (355/279 mm)
Hole size ..... 6" (152 mm)

Machine Capacities — Standard Equipment

Machine Size	Work Diameter	Grinding Wheel Width	Regulating Wheel Width	Main Drive Horsepower
220-8	1/16 to 4-1/2" (1.6 to 114 mm)	10" max. (254 mm)	10" max. (254 mm)	20 hp (15 kW)
230-12 TWIN GRIP	1/2 to 6" (12.7 to 152 mm)	12" max. (304 mm)	14" max. (355 mm)	30 hp (22 kW)
350-20 TWIN GRIP	1/2 to 6" (12.7 to 152 mm)	20" max. (508 mm)	20" max. (508 mm)	50 hp (37 kW)

MIL 000082

Simply Productive

The RK Series proves that outstanding precision is not out of your price range. Simple modular build and mechanical design combine with advanced features to make these machines remarkably accurate and affordable.

Cincinnati Milacron has reduced the number of parts in the RK Centerless by 42% while improving grinding performance. Pneumatics have been removed and most hydraulics have been replaced by smooth running servomotor drives.

Throughout the machine, automatic lubrication requirements have been eliminated by anti-friction slide-away systems. Complex computer programming has been replaced by simple state-of-the-art operator controls.

Quick Setup and Easy Operation

Mechanical design of the RK helps keep setup easy. The grinding wheel position is fixed, rigidly mounted to the machine bed. An upper/lower slide arrangement, under the regulating wheel and workrest, swivel together with a single adjustment for quick, accurate correction of taper or wheel contact.

Precision Components

RK machines are built on an epoxy granite base, selected for its superior rigidity, vibration damping and thermal characteristics.

RK centerless slides combine anti-friction ways, brushless AC servomotors, precision ballscrews and digital feedback. The result gives you two-way compensation with 0.000004" (0.1 micron) resolution.

Standard RK truing units are a highly damped design. They provide anti-friction servomotor-driven traverse and cam-type profiling. the grinding wheel truing diamond axis is servomotor-driven, coupled with a precision ballscrew and a double pre-loaded nut.

FILMATIC grinding wheel spindle bearings with hydrostatic lift provide long-lasting, hydrodynamic, self-centering support which is consistent under varying grinding loads. High dynamic and static rigidity provide 0.000004" (0.1 micron) rotational accuracy. The regulating wheel is rigidly supported at both ends by special hydrodynamic bearings.

Reliability

Simple systems are easily maintained, have less potential for down-time and require fewer spare parts.

With this in mind, Milacron's centerless experts researched our extensive library of designs, service records, run-off test results and customer reports. Incorporating such features as hydrostatic spindle lift and "S curve" slide acceleration to maximize ballscrew life, RK machines apply the latest technology in simple, durable, precision components.

ONEfeed DMC Grinding Control

One look at the RK's standard operator's station tells you a lot. It's a small unit with relatively few controls — easy to learn, easy to set up and easy to operate — yet packed with flexibility. RK machines are ONEfeed arranged, for infeed or thrufeed operation. Comprehensive diagnostics and cycle status display provide detailed operator information.

The heart of the system is a multi-axis DMC (Dedicated Motion Controller). Its simple, direct controls give you the accuracy, speed and consistency of servo control with the common sense operation of a manual machine.

Commonality and Support

If you have Cincinnati centerless grinding machines, you'll be able to use most of your existing profile cams and work support tooling on the RK Series machines.

Milacron has the machines, controls, wheels, fluids, training, service, parts and process expertise, providing a total support package that's second to none.

Grinding Wheel Grades

- General Purpose: 97A601-K6-VFME
- Precision Finishing: 29A801-J4-VRWE
- Ceramic: 3MSB801-J6-VSAE

(Larger diameter parts require slightly softer grades)

Standard Machine Features

- Epoxy granite machine base
- Single screw swivel adjustment
- Anti-friction slide-way systems throughout
- ONEfeed arrangement for infeed or thrufeed operation
- 0.000004" (0.1 micron) machine resolution
- Servomotor regulating wheel drive
- Multi-axis servomotor machine motions
- FILMATIC grinding wheel spindle bearings
- Externally mounted grinding wheel motor
- Stand-alone machine hydraulics
- Machine mounted electrical cabinet

Optional Equipment

- CNC grinding and regulating wheel truings
- Rotary diamond roll grinding wheel plunge dresser
- Variable frequency grinding wheel drive
- Automatic grinding wheel balancer
- Automatic gaging systems
- Coolant filtration and refrigeration equipment
- Autoloaders
- Various Programmable Controller alternatives

Recommended Starting Grades For Centerless Grinding

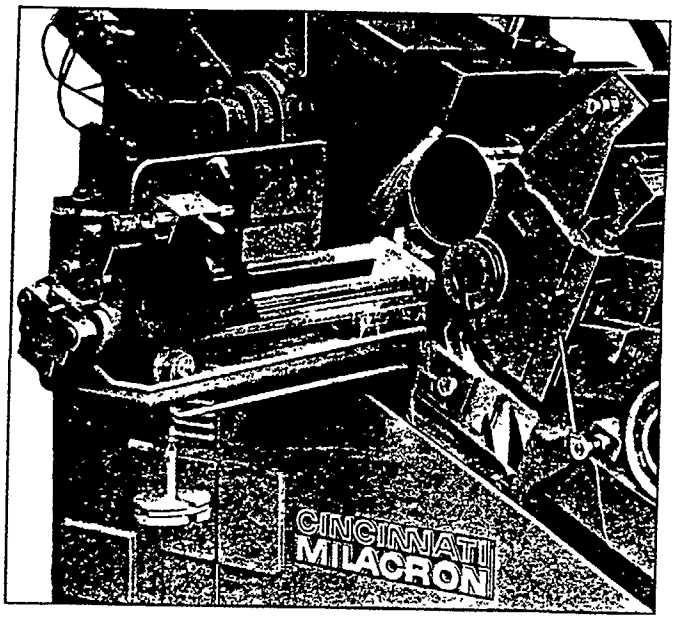
This chart is graded for 20 inch and 24 inch diameter wheels. If a machine requires a smaller wheel, use a grade one grade harder than grades shown in the chart.
For Hi production with optimum setup use VRW 1 grade softer.
For improved part quality with normal production and setup use VQC 1 grade softer.

Material Operation	Less than ½" Diameter	½" to 1½" Diameter	1½" to 3" Diameter	Over 3" Diameter
Alnico	12A60-L4-VFM	12A60-K4-VFM	12A60-J4-VFM	12A46-14-VA
Alnico	C12A601-P9-B90	C12A461-09-B90	C12A461-N9-B90	C12A461-M9-890
Aluminum Alloys (Hard)	97A601-J6-VFM	97A601-I6-VFM	97A601-H6-VFM	29A601-G6-VA
Aluminum Alloys (Soft)	6C46-L6-VSC	6C46-K6-VSC	6C46-J6-VSC	6C46-I6-VSC
Armature Shaft (Steel)	97A601-L4-VFM	97A601-K4-VFM	97A601-I4-VFM	29A601-H4-VA
Axles (Auto) Rough	—	97A601-M4-VFM	97A601-L4-VFM	—
Axles (Auto) Finish	—	97A801-M4-VFM	97A801-L4-VFM	—
Ball Bearings (Outer Ring)	97A801-K4-VFM	97A801-J6-VFM	97A801-I6-VFM	29A801-H6-VA
Bolts — Steel-Forged or Machined	97A601-N4-VFM	97A601-L4-VFM	97A601-J6-VFM	—
Brass and Bronze (Soft)	6C46-L6-VSC	6C46-K6-VSC	6C46-J6-VSC	6C46-J6-VSC
Bronze (Hard)	97A601-J4-VFM	97A601-I4-VFM	97A601-H6-VFM	29A601-H6-VA
Bushings (Soft Steel)	97A601-L4-VFM	97A601-K4-VFM	97A601-J6-VFM	29A601-I6-VA
Bushings (Hardened Steel)	97A801-K4-VFM	971801-J4-VFM	97A801-I6-VFM	29A801-H6-VA
Bushings (Cast Iron)	97A701-J4-VFM	97A701-I6-VFM	97A701-H6-VFM	29A701-G6-VA
Carbon	6C46-N6- VSC	6C36-M6-VSC	6C36-L6-VSC	6C36-K6-VSC
Cast Iron (General Purpose)	97A701-J4-VFM	97A701-I6-VFM	6C70-J6-VSC	6C70-I6-VSC
Ceramics (General Purpose)	6C80-L6-VSC	6C80-K6-VSC	6C80-J6-VSC	6C46-I6-VSC
Copper	6C60-L6-VSCD	6C46-L6-VSCD	6C60-K6-VSCD	6C46-I6-VSCD
Cylinder Liners	—	—	—	6C36-J6-VSC
Drills (Thru-Feed H.S.S.)	97A1201-N4-VFM	971801-M4-VFM	97A801-J4-VFM	—
Dowel Pins (Hardened)	97A801-L4-VFM	97A801-J4-VFM	97A801-I4-VFM	29A801-G6-VA
Glass — Ground Joints, Stoppers)	6C60-N6-VSC	6C60-L6-VSC	—	—
Glass — Fine Finish	6C220-M6-VSC	6C220-L6-VSC	—	—
Needles (Hypodermic)	97A1201-P4-VFM	—	—	—
Nitralloy — Bars Soft	97A601-M4-VFM	97A601-L4-VFM	97A601-K4-VFM	—
Nitralloy — Bars Hard	97A801-L4-VFM	97A801-K4-VFM	97A601-I6-VFM	—
Paper — Cardboard Tubes	6C36-K6-VSC	6C36-J6-VSC	6C36-J6-VSC	6C36-I6-VSC
Pistons — Aluminum	97A461-J6-VFM	97A461-I6-VFM	6C36-J6-VSC	6C36-I6-VSC
Pistons — Cast Iron	97A241-J6-VFM	97A461-I6-VFM	97A461-H6-VFM	29A461-H6-VA
Plastics — Tubing & Bar Stock	12A36-I6-VFM	6C60-J6-VSC	6C46-I6-VSC	6C36-H6-VSC
Roller Bearings	97A801-L6-VFM	97A801-K6-VFM	97A801-J6-VFM	29A801-I6-VA
Shafts — Steel, Armature				
Thru-Feed	97A601-L4-VFM	97A601-L4-VFM	97A601-K4-VFM	—
In-Feed	97A601-L4-VFM	97A601-K4-VFM	97A601-I6-VFM	—
Pump Shaft — Soft	97A601-L4-VFM	97A601-L4-VFM	—	—
Pump Shaft — Hard	97A801-L4-VFM	97A801-K4-VFM	—	—
Shock Absorber — Shaft Rough	97A801-V-BWK	97A801-L4-VFM	—	—
Shock Absorber — Shaft Finish	97A1201-V-BWK	97A1201-V-BWK	—	—
Steel (Soft) Thru-Feed	97A601-N6-B90	97A601-N9-B90	97A601-N9-B90	—
Steel (General Purpose)	97A601-M4-VFM	97A601-K6-VFM	97A601-I6-VFM	29A601-H6-VA
Hot Rolled Bars — General Purpose	C97A601-R9-B90	C97A601-P9-B90	C97A601-09-B90	C29A461-N9-B90
Cole Rolled Bars — General Purpose	97A601-09-B90	97A601-09-B90	97A601-N9-B90	29A461-M9-B90
Steel (High Speed)	97A801-K6-VFM	12A801-J6-VFM	12A801-I6-VFM	—
Steel (Drill Rod)	97A601-K6-VFM	97A601-J6-VFM	97A601-I6-VFM	—
Steel (Stainless)				
(Non-Free Machining)	6C60-M6-VSC	6C60-L6-VSC	6C60-J6-VSC	—
(Free Machining)	97A601-L6-VFM	12A60-K6-VFM	12A601-I6-VFM	—
Stellite	97A601-M4-VFM	97A601-L4-VFM	97A601-K4-VFM	—
Stoodite	6C60-M6-VSC	6C60-L6-VSC	6C60-K6-VSC	6C60-J6-VSC
Thread — Crush Dress				
18 Pitch & Coarser	12A220-04-VFM	12A220-M4-VFM	—	—
Titanium — Thru-Feed Bars	6C60-R9-B90	6C60-Q9-B90	6C60-P9-B90	—
Tubing — Steel				
Rough	97A461-J4-VFM	97A461-I6-VFM	97A461-H6-VFM	29A461-G6-VA
Finish	6C60-P9-B90	6C60-09-B90	6C60-N9-B90	6C60-L9-B90
Tungsten — Bars, Rods, Wire	6C80-M6-VSC	6C60-L6-VSC	6C60-K6-VSC	6C60-J6-VSC
IMP Diamond Roll Dress	97A801-04-VFM	97A801-N4-VFM	—	—
Crush Dress	97A1501-M4-VFM	97A1501-L4-VFM	—	—
Valves (Automotive)				
Stems — Rough	97A601-N4-VFM	97A601-M4-VFM	—	—
Stems — Finish	97A801-M4-VFM	97A801-L4-VFM	—	—
Valve Guides — Cast Iron	97A701-M4-VFM	97A701-L4-VFM	—	—
Valve Lifters — Steel	97A601-K4-VFM	97A601-J6-VFM	—	—
Chilled Iron	97A601-N4-VFM	97A601-M4-VFM	—	—
Zirconium — Bars Rough	6C60-R9-B90	6C60-P9-B90	—	—
Bars Finish	6C80-R9-B90	6C80-P9-B90	—	—

Centerless Wheels Commonly In Stock In Various Grades

Grinding Wheels	Regulating Wheels
24" x 20" x 12" (1 pc. or 2-10" sections)	14" x 20" x 6" (2 pc.)
24" x 18" x 12" (1 pc. or 2-9" sections)	14" X 12" X 5" (2 pc.)
24" x 12" x 12"	14" x 12" x 6"
24" x 20" x 12"	14" x 10" x 6"
24" x 8" x 12"	14" x 10" x5"
24" x 6" x 12"	13" x 10" x 6"
24" x 5" x 12"	13" x 10" x 6"
24" x 4" x 12"	13" x 10" x 5"
20" x 8" x 12"	12" x 8" x 5"
20" x 6" x 12"	12" x 6" x 5"
20" x 4" x 12"	12" x 4" x 5"

See Regulating Wheel Recess Chart



Unique grinding fixture for large bearing races

Machine:
440-20 TWIN GRIP
Centerless Grinding Machine

Part:
Bearing Races

Material:
52100 Bearing Steel

Hardness:
60-Rc

Stock:
.048

Finish:
20-25 RMS

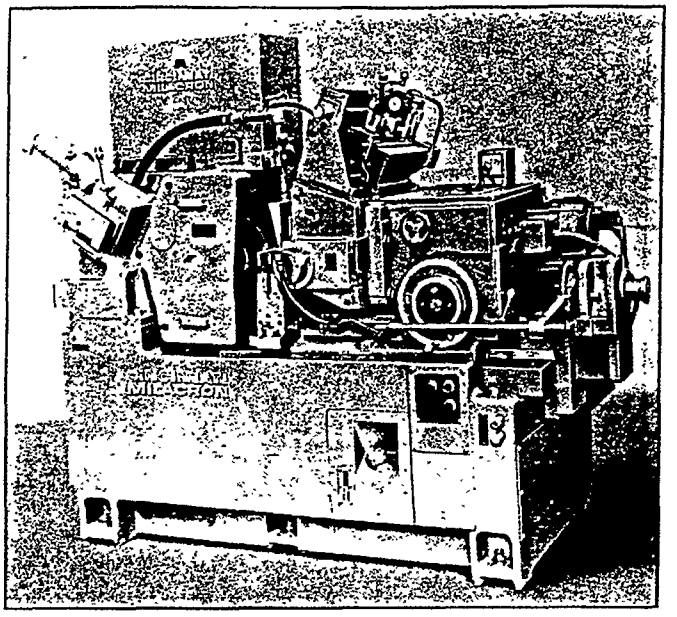
Type Of Operation:
Thru Feed

Wheel Grade:
97A701-I6-VFME
or 29A801-I8-VAE

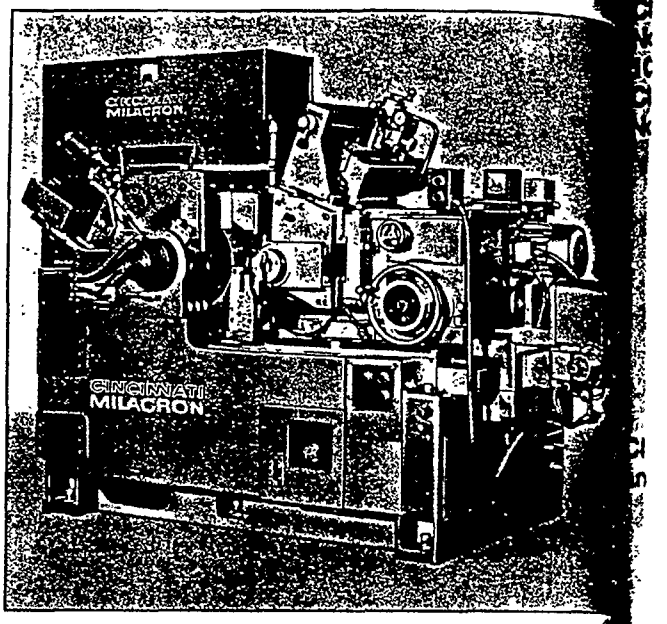
MIL 000085

Typical Machine Manufacturers

Bryant, Cincinnati Milacron, Landis, Norton, Gold Crown, Tschudin, Van Norman, White Sundstrand, Royal-Master



CINCINNATI MILACRON
220-8 Cantilever Type
Centerless Grinding Machine



CINCINNATI MILACRON
340-20 TWIN GRIP Type
Centerless Grinding Machine

Cincinnati Milacron Inc.
Cincinnati, OH

Machine/Model	Item	Wheel Size	Type
CINCINNATI No. O Old Style	Grinding Wheels	14" x 1" x 5"	
		14" x 1½" x 5"	
		14" x 2" x 5"	
		14" x 2½" x 5"	
		14" x 3" x 5"	T-1
	Regulating Wheels	7" x 1" x 2"	
		7" x 1½" x 2"	
		7" x 2" x 2"	T-1
	Grinding Wheels	14" x 3¼" x 5"	R-2/S 8" X ⅛"
		14" X 3½" X 5"	R-2/S 8" X ¼"
		14" X 3¾" X 5"	R-2/S 8" X ⅜"
		14" X 4" X 5"	R-2/S 8" X ½"
	Regulating Wheels	7" x 2¼" x 2"	R-2/S 3¾" x ⅛"
		7" X 2½" X 2"	R-2/S 3¾" X ¼
		7" X 2¾" X 2"	R-2/S 3¾" X ⅜"
		7" X 3" X 2"	R-2/S 3¾" X ½"
		7" X 3¼" X 2"	R-2/S 3¾" X ⅝"
		7" X 3¼" X 2"	R-2/S 3¾" X ¾"
		7" X 3¾" X 2"	R-2/S 3¾" X ⅞"
		7" X 4" X 2"	R-2/S 3¾" X 1"

MIL 000086

Cincinnati Milacron Inc.
Cincinnati, OH

Machine/Model	Item	Wheel Size	Type
CINCINNATI	Grinding Wheel	16" x 4" x 10"	
No. O New Style and 107-4	Regulating Wheel	9" x 4" x4"	R-2/S 5¼" X ⅝"
CINCINNATI	Grinding Wheels	20" x 3" x 12"	T-1
No. 2		20" x 4" x 12"	T-1
		20" x 5" x 12"	T-1
		20" x 6" x 12"	T-1
		20" x 7" x 12"	T-1
		20" x 8" x 12"	T-1
	Regulating Wheel	12" x 3" x 5"	R-1/S 7½" x ½"
		12" x 4" x 5"	R-2/S 7½" x ½"
		12" x 5" x 5"	R-1/S 7½" x ½" R-0/S 7½" x 1½"
		12" x 6" x 5"	R-1/S 7½" x ½" R-0/S 7½" x 1½"
		12" x 7" x 5"	R-2/S 7½" x 1½"
		12" x 8" x 5"	R-1/S 7½" x ½" R-0/S 7½" x 2½"
CINCINNATI No. 3	Grinding Wheels	24" x 3" x 12"	T-1
and No. 4		24" x 4" x 12"	T-1
		24" x 5" x 12"	T-1
		24" x 6" x 12"	T-1
		24" x 7" x 12"	T-1
		24" x 8" x 12"	T-1
		24" x 9" x 12"	T-1
		24" x 10" x 12"	T-1
	Regulating Wheels	14" x 3" x 5"	R-1/S 8" x 1½"
		14" x 4" x 5"	R-1/S 8" x 1½"
		14" x 5" x 5"	R-1/S 8" x 1½"
		14" x 6" x 5"	R-1/S 8" x 1½"
		14" x 7" x 5"	R-1/S 8" x 1½" R-0/S 8" x 1"
		14" x 8" x 5"	R-1/S 8" x 1½" R-0/S 8" x 2"
		14" x 9" x 5"	R-1/S 8" x 1½" R-0/S 8" x ½"
		14" x 10" x 5"	R-1/S 8" x 1½"
CINCINNATI	Grinding Wheels	24" x 8" x 12"	
CINCO 15	Regulating Wheels	12" x 8" x 5"	R-1/S 7½" x 1½"
CINCINNATI 230-10	Grinding Wheels	24" x 10" x 12"	
TWIN GRIP	Regulating Wheels	12" x 10" x 5"	R-1/S 7½" x 1½"
			R-0/S 7½" x 2"
CINCINNATI	Grinding Wheels	24" x 10" x 12"	T-1
300 Series		24" x 12" x 12"	T-1
TWIN GRIP		24" x 18" x 12"	T-1 1 or 2 sections
325-12		24" x 20" x 12"	T-1 1 or 2 sections
330-15			
340-20	Regulating Wheels	14" x 10" x 6"	T-1 or recessed 1/S
		14" x 12" x 6"	
		14" x 18" x 6"	2 sections recessed 1/S
		14" x 20" x 6"	2 sections recessed 1/S
			When Wheel cannot be made in one piece, it is best to order two equal sections.
CINCINNATI	Grinding Wheels	24" x 12" x 12"	T-1
400 Series			
CINCINNATI	Regulating Wheels	14" x 12" x 6"	T-1 or recessed 2/S
430-12			
TWIN GRIP	Grinding Wheels	24" x 20" x 12"	T-1
440-20	Regulating Wheels	14" x 20" x 6"	Recessed 2/S

Cincinnati Milacron Inc. (cont.)

Machine/Model	Item	Wheel Size	Type
CINCINNATI OMV-24	Grinding Wheel	24″ x 8″ x 12″	T-1
		24″ x 10″ x 12″	T-1
	Regulating Wheels	12″ x 8″ x 5″	R-1/S 7½″ x 1½″
		12″ x 10″ x 5″	R-1/S 7½″ x 2″
CINCINNATI 220-8 RK	Grinding Wheels	24″ x 8″ x 12″	T-1
		24″ x 10″ x 12″	T-1
	Regulating Wheels	14″ x 8″ x 6″	T-1
		14″ x 10″ x 6″	R-2/S 8¾″ x 1″
230-12 RK	Grinding Wheels	24″ x 12″ x 12″	T-1
		24″ x 14″ x 12″	T-1
	Regulating Wheels	14″ x 12″ x 6″	T-1
		14″ x 14″ x 6″	R-2/S 8¾″ x 1″ (17762Y)
350-20-RK	Grinding Wheel	24″ x 20″ x 12″	T-1
	Regulating Wheel	14″ x 20″ x 6″	R-2/S 8¾″ x 1½″ (3800Y)
CINCINNATI 220-8 AE	Grinding Wheels	24″ x 8″ x 12″	T-1
		24″ x 10″ x 12″	R-1/S 14⅝″ x ¾″
	Regulating Wheels	15″ x 8″ x 6″	T-1
		15″ x 10″ x 6″	R-2/S 8¾″ x 1″
230-12 AE	Grinding Wheel	24″ x 12″ x 12″	T-1
	Regulating Wheel	15″ x 12″ x 6″	T-1
350-20 AE	Grinding Wheel	24″ x 20″ x 12″	T-1
	Regulating Wheel	15″ x 20″ x 6″	R-2/S 8¾″ x 1½″ (13168Y)
CINCINNATI Centerless Lapping Machine	Grinding Wheels	14″ x 22″ x 6⅜″	T-1
	Regulating Wheels	14″ x 22″ x 6⅜″	T-1

Bryant Grinder Corp., Springfield, VT (machines formerly built by Van Norman)

Machine/Model	Item	Wheel Size	Type
1C (new)	Grinding Wheels	16″ x 4″ x *	May be
	Regulating Wheels	8″ x 4″ x *	recessed
1M	Grinding Wheels	14″ x .375″ x 5″	
	Regulating Wheels	2.500″ x .311″ x 1.000″	
45M	Grinding Wheels	14″ x .500″ x ″	1
	Regulating Wheels	none	
2CH	Grinding Wheels	24″ x 8″ x 12″	recessed
	Regulating Wheels	12″ x 8″ x 5″	recessed
3CH	Grinding Wheels	24″ x 12″ x 12″	recessed
	Regulating Wheels	12″ x 12″ x 5″	recessed
		*Numerous sizes apply to this machine.	

Landis Tool Co.

Machine/Model	Item	Wheel Size	Type
	Grinding Wheels	20" x 4" x 12"	T-1
		20" x 5" x 12"	T-1
		20" x 6" x 12"	T-1
		20" x 8" x 12"	
		20" x 8" x 12"	T-2/S 14" x 1"
LANDIS No. 12	Regulating Wheels	12" x 4" x 5"	T-1
		12" x 5" x 5"	T-1
		12" x 6" x 5"	T-1
		12" x 8" x 5"	T-1
		12" x 4" x 5"	R-2/S 7½" X ½"
		12" X 5" X 5"	R-1/S 7½" X ½" R-0/S 7½" X 1½"
		12" X 6" X 5"	R-1/S 7½" X ½" R-0/S 7½" X 1½"
		12" X 8" X 5"	R-1/S 7½" X ½" R-0/S 7½" X 2½"
LANDIS No. 121/2	Grinding Wheels	24" x 4" x 12"	T-1
		24" x 6" x 12"	
		24" x 8" x 12"	
		24" x 10" x 12"	
	Regulating Wheels	14" x 4" x 5"	R-1/S 8" X 1"
		14" X 6" X 5"	R-1/S 8" X 1½"
		14" X 8" X 5"	R-1/S 8" X 1½" R-0/S 8" X 2"
		14" X 10" X 5"	R-2/S 8" X 1½"
LANDIS 12R	Grinding Wheels	20" x 8" x 12"	May be recessed
	Regulating Wheels	12" x 8" x 5"	May be recessed
LANDIS 14R	Grinding Wheels	24" x 14" x 12"	May be recessed
	Regulating Wheels	14" x 14" x 5"	May be recessed
LANDIS 24CR	Grinding Wheels	24" x 14" x 12"	May be recessed
	Regulating Wheels	24" x 12" x 5"	May be recessed

Most infeed jobs require a 1-piece grinding wheel or 2-piece wheel cut on a bias.

Van Norman Co., Springfield, MA

Machine/Model	Item	Wheel Size	Type
No. 1C	Grinding Wheels	14" x 4" x 8"	R-2/S 10½" x ½"
	Regulating Wheels	8" x 4" x 3"	R-1/S 4¼" X ½"
			R-0/S 4¼" X 1½"
No. 2C	Grinding Wheels	24" x 4" x 12"	T-1
		24" x 6" x 12"	R-1/S 14" X ½" R-0/S 14" X 1½"
		24" x 8" x 12"	R-1/S 14" X 1½" R-0/S 14" X 2½"
	Regulating Wheels	12" x 4" x 5"	R-2/S 7½" x ½"
		12" x 6" x 5"	R-1/S 7½" x ½" R-0/S 7½" x 1½"
		12" x 8" x 5"	R-1/S 7½" x 1½" R-0/S 7½" x 2½"

White-Sundstrand, Syracuse, NY

Machine/Model	Item	Wheel Size	Type
Model 20	Grinding Wheels	24" x 20" x 12"	(usually 2-10" sections)
	Regulating Wheels	16" x 20" x 10"	(usually 2-10" sections)

Royal Master, Inc.
Riverdale, NJ

Machine/Model	Item	Wheel Size	Type
Model PG-7	Grinding Wheels	7″ x 8⅝″ x 1.500″	
	Regulating Wheels	3⅝″ x 8¼″ x 1.000″	
Model TG-12	Grinding Wheels	12″ x 3″ x 5″	T-1
	Regulating Wheels	6″ x 3″ x 1″	
Model TG 12 x 4	Grinding Wheels	12″ x 4″ x 5″	R-2/S 7½″ x ½″
	Regulating Wheels	6″ x 4″ x 1″	
Model DRF 12	Grinding Wheels	12″ x 3″ x 5″	various recesses
	Regulating Wheels	6″ x 3″ x 1″	
Model CG 12	Grinding Wheels	12″ x 3″ x 5″	various recesses
	Regulating Wheels	6″ x 3″ x 1″	
Model TG 12GB	Grinding Wheels	12″ x 3″ x 5″	various recesses
	Regulating Wheels	6″ x 3″ x 1″	
		If wheel is mounted on a steel bushing, customer should supply Cincinnati with bushings.	

Norton Co.,
Worcester, MA

Machine/Model	Item	Wheel Size	Type
	Grinding Wheels	20″ x 3″ x 12″	T-1
		20″ x 4″ x 12″	T-1
		20″ x 5″ x 12″	T-1
		20″ x 6″ x 12″	T-1
		20″ x 7″ x 12″	T-1
		20″ x 8″ x 12″	T-1
No. 2	Regulating Wheels	12″ x 3″ x 5″	T-1
		12″ x 4″ x 5″	T-1
		12″ x 5″ x 5″	T-1
		12″ x 6″ x 5″	T-1
		12″ x 7″ x 5″	T-1
		12″ x 8″ x 5″	T-1

Recessed wheels such as used on the Cincinnati No. 2 and Landis No. 12 may be used, with spacers.

MIL 000090

Centerless Grinding
Material and Specifications

Material	Specification
ALUMINUM	7C461-J10-VSC
AXLES, Automobile	29A601-L4-VFM
BALL BEARING RINGS	29A801-J8-VA
BARS	
Steel	97A541-P6-B90
Stainless (300 Series)	C2A541-Q6-B90
Brass and Bronze	C2A541-P6-B90
BRASS	6C46-N6-B90
BRONZE	6C46-N6-B90
CARBON, Hard	6C80-K6-VSC
CAST IRON	6C80-M6-VSC
CEMENTED CARBIDES	CMD120-N100-B
DRILLS and REAMERS	
Hard	29A801-K4-VFM
Soft	97A601-L6-VFM
FORGINGS	97A601-N6-VFM
PIPE BALLS, Manganese Steel	
Roughing	97A461-N6-VFM
Finishing	29A601-K6-VFM
PISTONS	
Aluminum Alloy	6C46-K6-VSC
Cast Iron	6C46-M6-VSC
PISTON PINS	29A601-L4-VFM
RUBBER, Hard	7C541-J6-VSC
SPLINE SHAFTS	97A601-L4-VFM

Material	Specification
STEEL	
Hardened	29A801-K4-VFM
High Speed	29A801-K4-VFM
Soft	97A601-L6-VFM
Stainless	
Heat Treated	7C601-K4-VSC
Free Machining	29A541-L6-VFM
TUBING, Steel	29A601-K8-VA
TUNGSTEN RODS	7C801-L4-VSC
VALVE STEMS, Automotive	97A1001-N4-VFM
VALVE TAPPETS	97A1001-N4-VFM
GENERAL PURPOSE	29A601-K6-VFM
REGULATING WHEEL	
General Purpose	A80-R2-R
	A80-R2-RFW
Bar Grind	A80-R2-R
	A80-R2-RFW
Small Parts	A120-T2-R
Very Small Parts	A280-T2-R
VITRIFIED REGULATING WHEEL	
For parts with interrupted surfaces such as holes, flats, grooves and keyways:	
General Purpose	2A100-P4-VFME1
Small Parts	2A120-R4-VFME1
Very Small Parts	2A150-T4-VFME1

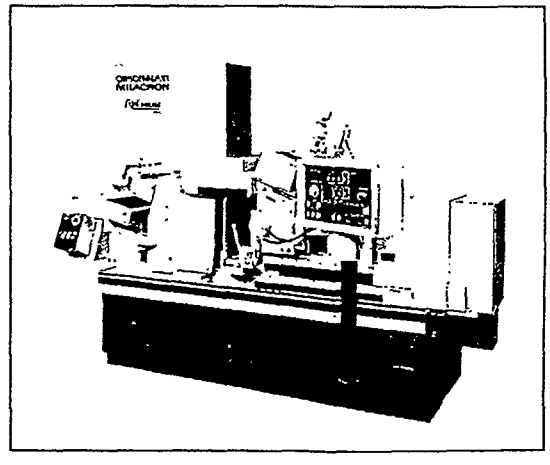
RK Centerless Grinder Brief Specifications

Grinding Wheel
Diameter maximum/minimum ..... 24/17" (609/431 mm)
Hole size ..... 12" (304 mm)

Regulating Wheel
Diameter maximum/minimum ..... 14/11" (355/279 mm)
Hole size ..... 6" (152 mm)

Machine Capacities — Standard Equipment

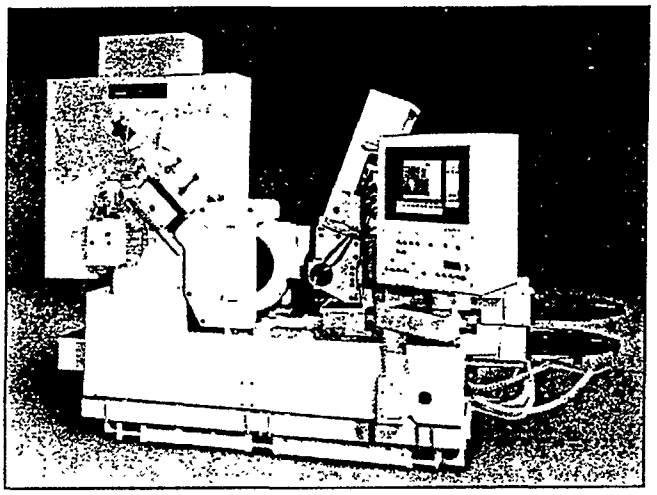
Machine Size	Work Diameter	Grinding Wheel Width	Regulating Wheel Width	Main Drive Horsepower
220-8	1/16 to 4-1/2" (1.6 to 114 mm)	10" max. (254 mm)	10" max. (254 mm)	20 hp (15 kW)
230-12 TWIN GRIP	1/2 to 6" (12.7 to 152 mm)	12" max. (304 mm)	14" max. (355 mm)	30 hp (22 kW)
350-20 TWIN GRIP	1/2 to 6" (12.7 to 152 mm)	20" max. (508 mm)	20" max. (508 mm)	50 hp (37 kW)



RK Series 220-8 Centerless Grinder
8500 SFPM

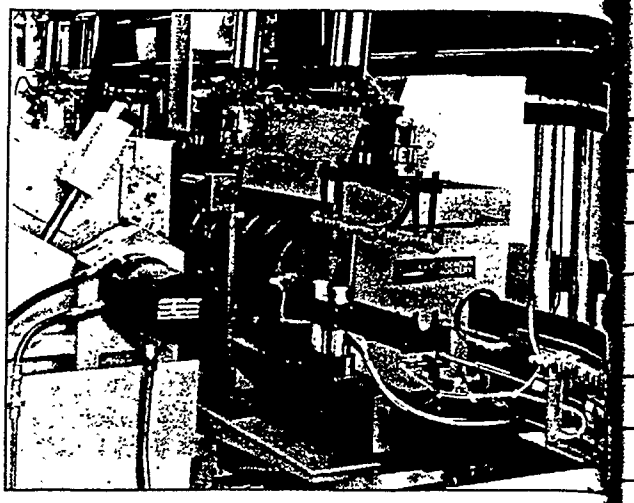
Typical Wheel Grades:
Finishing — 29A801-K4-VFME
Roughing — 97A601-L6-VFME

MIL 000091



Gold Crown 200

Grinding Wheel 24" x 8" x 12"
Regulating Wheel 14" x 8" x 6" No Recess

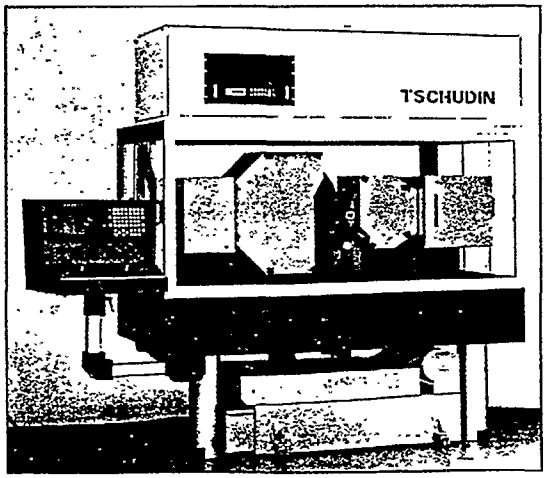


Gold Crown 660

Grinding Wheel 24" x 26" x 12"
Regulating Wheel 14" x 26" x 6"
R (2 Sides) 8¾" x 1½"
For work up to 6" Dia.

Additional Gold Crown Machines

	Grinding Wheel	Regulating Wheel
GC 500	24" x 20" x 12"	14" x 20" x 6" (3800Y)
GC 500 ER	24" x 20" x 12"	14" x 20" x 6" (3800Y)
15 Slant Bed		
GC300	24" x 12" x 12"	14" x 12" x 6" (S/S)
GC250	24" x 10" x 12"	14" x 10" x 6" (R-1/S 8¾" x 1½")



Tschudin CNC 600 Series

Typical Wheel Size:
Grinding Wheel 24" x 14" x 12"
Regulating Wheel 14" x 14"x 8"

Typical Wheel Grades:
29A601-K6-VFME or 3MSB-601-J4-VSAE

MIL 000092

Wheel Sizes And Machine Data For Centerless Grinders

* = Special ** = 2" Recess *** = Full Range **** = Machines after June, 1965 Have 6" Spindle

MACHINE	Center Height Above Workrest Pod	Grinding Wheel Maximum Diameter	Grinding Wheel Minimum Diameter	Grinding Wheel Width	Grinding Wheel Hole Size	Regulating Wheel maximum Diameter	Regulating Wheel Minimum Diameter	Regulating Wheel Width	Regulating Wheel Hole Size	Grinding Wheel Motor Drive - HP	Thrufeed	Infeed	XXX Long Bar	Low Thrufeed Workrest	Cutting fluid Tank Capacity Gallons
#0 LO	6-15/16	16	12	4	10	9	7	4	4	.5	0-½	0-½			40
#1 LM	6-15/16	16	12	4	10	9	7	4	4	7½	0-½	0-½		40	
#2 EA&OM	8-7/16	20	14½	8	12	12	9½	8	5	15	0-3	0-3	½-4	2-4¾	65
#2 LO	9⅞	20	15	8	12	12 or 13	10	10**	5	20	1/16-3	1/16-3	1/16-4	2-4¾	65
#3 EA	9⅞	24	16	10*	12	14	10	12**	5	25	1/2-3	1/2-6	1/2-4	2-6	65
#3 LL	9⅞	24	16	12, 15, 20	12	14	10	**12 15, 20	5	30	½-3	½-6	½-4	2-7	65
#4 EA	9⅞	24	16	10*	12	14	10	12**	5	25	½-6	½-6		2-7½	65
#5 EA		24	16	36	12	16	10	36	8	50	1-7	1-7			150
#6 EA		30 or 36		36	12	14	10	36	8	60	1-10	1-10			150
CINCO-15 DE	8-7/16	20	15	8	12	12	9¾	8	5	15	1/16-3	1/16-3	1/8-1¼		65
CINCO-15 DR	8-7/16	24	17	8	12	12 to 15	9½	8	5	15	1/16-3	1/16-3	1/8-1¼		65
#1 DR	6-15/16	16	12	4	10	9	7	4	4	7½	0-1½	0-1½			40
#210-6 LR	9⅞	20	15	6	12	12	9¾	6	5	10	0-3	0-3	1/16-2½	2-4	75
#220-8 LR	9⅞	20	15	8	12	13	9¾	8	5	20	0-3	0-3	1/16-2½	2-4	75
#220-8 DE	9⅞	24	17	8	12	13	9¾	8	5	20	0-4½	0-4½	½-4	2-4½	75
#230-10 DA	9⅞	24	17	10	12	13	10½	10	5	30	¼-4	¼-4	½-4	2-4½	150
#325-12 DE	9⅞	24	17	12	12	14	10½	12	5	25	½-6	½-6	½-4	2-4½	150
#330-15 DE	9⅞	24	17	15	12	14	10½	15	5	30	½-6	½-6	½-4	2-4½	150
#340-20 DE	9⅞	24	17	20	12	14	10¼	20	5	40-100	½-6	½-6	½-4	1-8	150
#430-12 DE	9⅞	24	17	12	12	14	10½	12	5****	30	1-10	1-10		1-4	150
#440-20 DE	9⅞	24	17	20	12	14	101/4	20	5****	40	1-10	1-10		1-4	150
#2 OMV-24	9⅞	24	17	MAX 10	12	12	10	10	5	15	1/16-3	1/16-3			65
#220-8 AE	11	24	17	MAX 10	12	15	11	MAX 10	6	25	1/16-4½	1/16-4½			75
#230-12 AE	11	24	17	12	12	15	11	12	6	25-30	½-6	½-6			150
#350-20 AE	11	24	17	20	12	15	11	20	6	50-100	½-6	½-6			150
#220-8 RK	11	24	17	MAX 10	12	14	10	MAX 10	6	25	1/16-4½	1.16-4½			75
#230-12 RK	11	24	17	MAX 14	12	14	10	MAX 14	6	25-30	½-6	½-6			150
#350-20 RK	11	24	17	20	12	14	10	20	6	50-100	½-6	½-6			150

MIL 000093

CINCINNATI Centerless Grinders Regulating Wheels Sizes

Machine	Dimensions	Recess
#0-EH	7" x ½" x 2"	
	7" x 3" x 2"	R-2/S 3¾" X ½"
	7" X 4" X 2"	R-2/S 1" X 1"
#0-#1-NEW	9" x ½" x 4"	
	9" x 3" x 4"	R-2/s 5½" X ⅛"
	9" X 4" X 4"	R-2/S 5½" X ⅝"
#2 (EA) (OM)	12" X 3" X 5"	R-1/S 7½" X ½"
	12" X 4" X 5"	R-2/S 7½" X ½"
	12" X 5-6" X 5"	R-1/S 7½" X 1½"
		R-0/S 7½" X ½"
	12" X 7" X 5"	R-2/S 7½" X 1½"
	12" X 8" X 5"	R-1/S 7½" X 1½"
		R-0/S 7½" X 2½"
#2-LO	12" X 3-4" X 5"	R-1/S 7½" X ½"
	12" X 5-8" X 5"	R-1/S 7½" X 1½"
#2-LR	12" X 3" X 5"	
	12" X 4" X 5"	R-1/S 7½" X ½"
	12" X 5" X 5"	R-1/S 7½" X 1"
	12" X 6-8" X 5"	R-1/S 7½" X 1½"
	12" X 10" X 5"	R-1/S 7½" X 1½"
		R-0/S 7½ X 2
#3-LL	14" X 4-11" X 5"	R-1/S 8" X 1½"
	14" X 12" X 5"	R-1/S 8" X 2"
#3-LR (Balancer)	14" x 4" x 5"	R-1/S 8" X 1½"
	14" X 5" X 5"	R-1/S 8" X 1"
	14" X 6-10" X 5"	R-1/S 8" X 1½"
	14" X 12" X 5"	R-1/S 8" X 1½"
		R-0/S 8" X 2"
(After 1-61)	14" x 12" x 5"	R-2/S 8" X 1½"
#3-4 LR	14" X 4" X 5"	R-1/S 8" X 1½"
(Non-Balancer)	14" x 5" x 5"	R-1/S 8" X ½"
	14" X 6-10" X 5"	R-1/S 8" X 1½"
	14" X 12" X 5"	R-1/S 8" X 2"
		R-0/S 8" X 1½"
	14" X 15" X 5"	R-2/S 8" X 1½"
	14" X 20" X 5"	R-2/S 8" X 1½"
#5-6 Lapper	16" x 1-6" x 8"	
	14" x 1-6" x 8"	
	14" x 22" x 6⅜"	

Requirements For Regulating Wheel Recesses

Machine	Dimensions	Recess
#1-LM	9" x4" x 4"	R-2/S 5½" X ½"
#325-12 Print #3988-Y	14" x 15" x 6"	R-2/S 8½" X 1½"
#330-15 Print #3988-Y	14" x 15" x 6"	R-2/S 8½" X 1½"
#430-12 Print #5988-Y	14" X 15" X 6"	R-2/S 8½" X 1½"
#220-8 DE & LR	12" X 4" X 5"	R-1/S 7½" X ½"
	12" x 5" x 5"	R-1/S 7½" X 1"
	12" X 6" X 5"	R-2/S 7½" X 1½"
	12" X 7" X 5"	R-1/S 7½" X 1½"
	12" X 8" X 5"	R-1/S 7½" X 1½"
#220-8 DE only	12" X 10" X 5"	R-1/S 7½" X 2"
		R-0/S 7½" X 1½"
#CINCO-15	12" X 3" X 5"	R-1/S 7½" X ½"
All requirements	12" X 4" X 5"	R-1/S 7½" X ½"
for 12" regulating	12" X 5" X 5"	R-1/S 7½" X 1½"
wheels will also	12" X 6" X 5"	R-1/S 7½" X 1½"
apply to 14" & 15"	12" X 7" X 5"	R-1/S 7½" X 1½"
diameter	12" X 8" X 5"	R-1/S 7½ X 1½"
regulating wheels		
Old TWIN GRIP #340-20 Print #1709-Y	14" X 20" X 5"	R-2/S 8" X 1½"
#440-20 Print #1709-Y	14" x 20" x 5"	R-2/S 8" X 1½"
New TWIN GRIP #340-20 Print #3800-Y	14" X 20" X 6"	R-2/S 8½" X 1½"
#440-20 Print #3800-Y	14" X 20" X 6"	R-2/S 8½" X 1½"
AE 220-8	15" X 8" X 6"	R-1/S 8½" X 1½"
AE 230-12	15" X 12" X 6"	R-2/S 8½" X 1½"
AE 350-20	15" X 20" X 6"	R-2/S 8¾" X 1½" BP12168Y
RK 220-8	14" X 8" X 6"	R-1/S 8½" X 1½"
RK 230-12	14" X 12" X 6"	R-1/S 8½" X 1½"
RK 350-20	14" X 20" X 6"	R-2/S 8¾" X 1½" BP3800Y

MIL 000094

CINCINNATI Centerless Grinder Regulating Wheel Bonds

Regulating wheels are available in three bond systems: BR, vitrified, and rubber.

Bond Type	Grain Type	Grit Size	Grades
BR	A	80, 100, or 120	R
Vitrified, VFME1	2A	80, 100 or 120	N4, P4, Q4-VFME1
Rubber R	A	80 & 120	R2, S2, or T2

*For additional grades consult your Cincinnati Milacron Marketing Company representative.

Description

BR Bond — A resilient resin general purpose bond used largely in thrufeed grinding with waterbased grinding fluid. Popular in price and availability. Works well when roundness limit is above .0002 inches. (Recommended starting grade is A80-R-BR.)

Rubber Bond — The standard rubber bond which has been the most popular regulating wheel due to the resiliency and gripping action of the rubber bond. Slightly higher in price and manufacturing time is slightly longer. (Recommended starting grade is A80-R2-R.)

Vitrified Bond — (VFME1) Vitrified regulating wheels can help to overcome roundness problem jobs in centerless grinding.

Here are some do's and don'ts for using vitrified regulating wheels.

Do Use

1. For parts with interrupted surfaces when roundness is critical, i.e., keyways, holes, notches.
2. For both thrufeed and infeed jobs, when roundness is critical.
3. For parts that have an eccentric action during the grind.

Don't Use

1. For bar grinding and thrufeeding rough parts (you still need the resiliency of resin on these jobs).
2. Under 1" thick except in special cases where the part is extremely small.
3. On double diameter parts when there is an extreme difference in diameter ratios.

Grades

There does not appear to be a need for many grades. 2A80-P4-VFME1 has been very successful although other standard vitrified grades can be used.

On small parts (less than ½") there may be a need to go finer and harder. 2A120-Q4-VFME1 (especially if the part has an intricate form).

CINCINNATI Centerless Lapping Wheels

Cincinnati Milacron formerly made a centerless lapper for producing fine finishes on cylindrical parts. the wheel system consisted of a lap grinding wheel and a regulating wheel.

Wheel Size

14 x 22 x 6⅜
3-14 x 7.335 x 6⅜ Sections

Wheel Speeds

Lap Grinding Wheel - 600 RPM
Regulating Wheel - 300 RPM

Product Availability

Grain Type		Grit Size	Grade	Structure
VFM	2A	120, 150, 180, 220	F-R	4
V10	A	120, 150, 180, 220	F-S	4-7
V80	A	180, 220	O-T	5
BY	C	320, 500	T-V	No Structure

Recommendations For Typical Operation

Regulating Wheel	Lap Grinding Wheel	Finish Required
C320-V-BY	2A220-R4-VFME1	Regular Lap Grind
C320-V-BY	C320-V-BY	6-8 RMS
C320-V-BY	C500-T-BY	4 RMS & Less

Formula for Computing "G" Ratio On Centerless Grinder

Do you have the occasion to compute a "G" ratio on centerless grinding? If so, here are the formulas you need.

$$\pi \times D \times \text{Stock on Radius} \times L = \text{Steel}$$

and

$$\pi \times D \times W \times \text{Compensation} = \text{Wheel}$$

Divide Wheel into Steel

Remember, although much higher "G" ratios are not as meaningful on semi finish or finish passes.

Consider vitrified regulating wheels for work pieces which have interrupted surfaces, such as holes, flats, grooves. keyways and etc.

Vitrified regulating wheels grades are:

General Purpose	2A100-P4-VFME1
Small Parts	2A120-R4-VFME1
Very Small Parts	2A150-T4-VFME1

MIL 000095

The position of the center of the work in relation to the centerline of the wheels is the same for infeed as thrufeed. Raise the center of the work above the centerline of the wheel an amount equal to 1/2 the work diameter for work 1" diameter and smaller, to 1/2" maximum for work larger than 1".

The regulating wheel truing slide is swiveled the same amount as the angle of inclination except when truing a special shape form the profile truing cam. When truing from the cam, the slide should be set at zero.

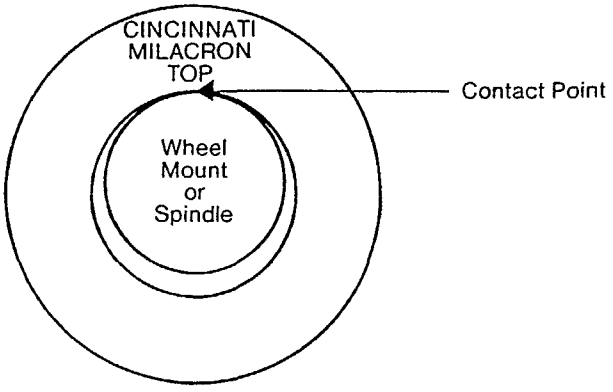
The diamond holder should be set over for infeed work the same as for thrufeed work; however, if dressing a special shape from the profile cam, the diamond holder should be set at zero.

The workpiece may be set at any height above center to obtain required roundness. With a small angle of inclination, the line of contact of the workpiece will be full at any height above center. However, if the angle of inclination is increased beyond 1/4°, the full line of contact will not result and further corrections will have to be made to set full line contact between the regulating wheel and workpiece.

How To Use "Top" Mark When Mounting CINCINNATI MILACRON Grinding Wheels

On-Machine Mounting

The TOP mark indicates the point of contact between wheel and spindle when the wheel's OD was trued at Cincinnati. Wheel user should mount wheel in the same way (i.e. align TOP with point of contact) to minimize OD runout and truing. Typical mountings are shown schematically below.



Mounting Wheels On TWIN GRIP Centerless Grinders

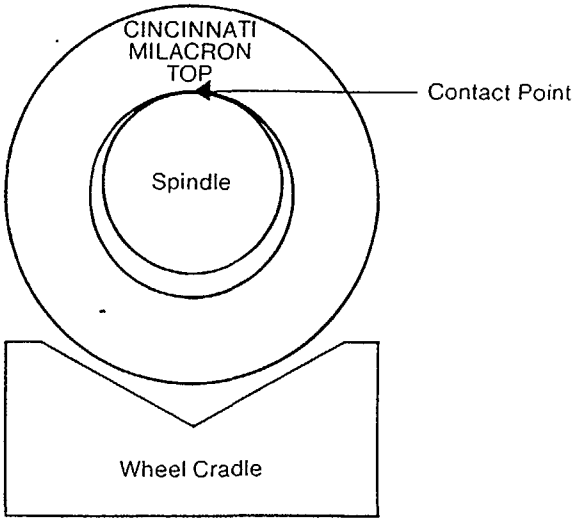
The Operators Hand Book has a comprehensive section on proper wheel mounting methods. Here are a few tips to make the job easier.

1. With wheels resting in cradle, install rear blotter, insert the spindle cartridge.
2. Install front blotter, flange, and bolts and snug up finger tight.

Off-Machine Mounting Of TWIN GRIP Wheels

Set wheel on cradle with TOP at 12 o'clock position. Place a blotter on fixed flange and insert spindle into wheel bore. Place a blotter on loose flange and mate flange with spindle; secure it with one screw, finger tight. Lift spindle-wheel assembly off cradle as shown.

Insert remaining flange screws and tighten them, in approved manner, while wheel is suspended as shown. *See photo opposite page.*



3. Raise assembly from the cradle, and tighten bolts with a torque wrench. *NOTE*: Wheel should be mounted with *top up.*
4. For wide wheel twingrips (18-20"), torque bolts to 45 foot pounds; for smaller twingrips (10-12") 35 foot pounds is sufficient.
5. Retorque the clamping flange bolts after the first 8 hours of operation.

tions when needed. The harder grades are used when the regulating wheels must be very thin and the general-purpose grade deflects under the pressure of the grind. Harder grades also offer some advantage when work must be ground to very close tolerances, and when there is excessive regulating wheel wear due to the design of the work when grinding two or more diameters and one is much larger than the other. The difference in sfpm causes one of the diameters to slip or skid in contact with the wheel. The general-purpose grade gives a better drive or braking action and will resist spinning more than the finer, harder wheels on average work. The average starting speed of the regulating wheel is from 22 to 39 rpm, and for general work the angle of inclination of 3° is recommended as a starting point. However, both the angle and wheel speed can be changed to suit specific conditions. The steeper the angle, the faster the traverse rate. The flatter the angle, the slower the traverse rate.The wheel speed also affects the traverse rate. The faster the wheel speed, the faster the traverse rate, and conversely, the slower the wheel speed, the slower the traverse rate. For work that is warped from hardening or machining, the best straightening effect can be obtained by using a high traverse rate or by increasing the angle of the regulating wheel. For work that is straight, but out-of-round, a faster rounding-up action can be obtained by using a higher regulating wheel speed and a flatter angle. This does not necessarily mean less production from the machine, because increasing the wheel rpm and reducing the angle of the regulating wheel could give approximately the same traverse rate.

Truing The Regulating Wheel: Thrufeed Work

The regulating wheel must be trued to a special shape so that the work, while passing between the wheels, makes a straight-line contact with the wheel face. Four factors must be considered to set the truing unit to form this shape:

1. Angle of inclination of the regulating wheel.
2. Location of the center of the work with respect to the centerline of the grinding and regulating wheels.
3. The angle to which the regulating wheel truing slide is swiveled.
4. The amount the diamond holder is set over.

The first factor is fixed by the work. A general recommendation for most thrufeed setups is a positive inclination of 3° as a starting point.

The second factor is fixed by the diameter of the work. Generally, work is ground with its center above the centerline of the grinding and regulating wheels. For small work up to 1" diameter, adjust the blade to position the work one half of its diameter above the centerline of the wheels. For larger work, the above center adjustment seldom exceeds 1/2 inch.

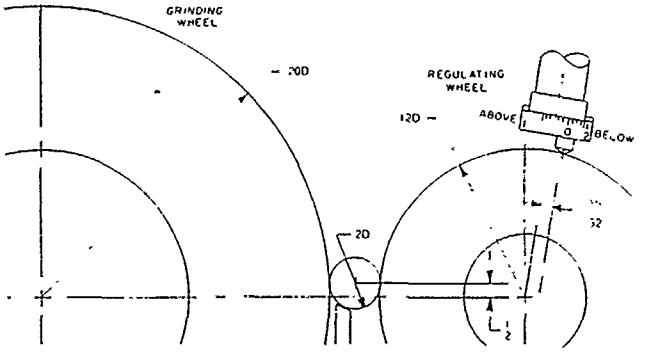
The third and fourth factors are based on the ratio of the diameter of the regulating wheel and the diameter of the workpiece. Determine the ratio by dividing the diameter of the regulating wheel by the diameter of the workpiece. After establishing this ratio, refer to the following chart to determine the correct truing angle for the truing slide and the correct diamond holder setting for dressing the special shape required on the regulating wheel.

Table Of Truing Angles And Heights Above Center For Regulating Wheel Truing

	Truing Angle Setting											
WORK FEED ANGLE*	7	6 10'	6 10	6 20'	6 25'	6 30'	6 35	6 45'	6 50	6 55	6 55
	6	5 15'	5 15	5 25'	5 30'	5 35	5 40'	5 45'	5 55	5 55	5 55'
	5	4 20'	4 25	4 30'	4 35'	4 40'	4 40'	4 50'	4 55	5	5
	4	3 30'	3 30	3 35'	3 40'	3 45'	3 45'	3 50'	3 55'	4	4
	3	2 35'	2 40'	2 40'	2 45	2 50'	2 50'	2 55'	2 55'	3	3
	2	1 45'	1 45'	1 50'	1 50'	1 50'	1 55	1 55'	2	2	2
	1	50'	50'	55'	55'	55'	55'	55'	1	1	1
RATIO D/d		3	3.5	4	5	6	7	12	18	24	48
WORK HEIGHT ABOVE CENTER†	1/8"	7/64"	7/64"	7/64"	7/64"	7/64"	1/8"	1/8"	1/8"	1/8	1/8"
	1/4"	7/32"	7/32"	7/32"	15/64"	15/64"	15/64"	15/64"	1/4"	1/4	1/4
	3/8"	21/64"	21/64"	11/32"	11/32"	11/32"	23/64	23/64"	23/64"	3/8	3/8
	1/2"	7/16"	7/16"	29/64"	29/64"	15/32"	15/32"	31/64"	31/64"	1/2	1/2"
	5/8"	35/64"	35/64"	9/16"	37/64"	37/64"	19/32"	19/32"	29/64"	5/8	5/8"
	3/4"	21/32"	21/32"	43/64"	11/16"	45/64"	45/64"	23/32"	47/64"	47/64	47/64
	7/8"	3/4"	29/64"	25/32"	51/64"	13/16"	55/64	27/32"	55/64	55/64	55/64
	1"	55/64"	7/8"	29/32"	59/64	15/16"	15/16"	61/64"	63/64"	63/64	63/64

To use the chart, consider a setup with a 3° angle of inclination, 2 work diameter, 1/2" height above center, 12" diameter regulating wheel.

To determine the ratio, divide the diameter of regulating wheel by the diameter of the work (12 divided by 2 = 6 ratio). Note chart — ratio 6 — read up on the chart to the line extending from 3° — note angle to swivel truing slide is 2°50'. To determine the diamond holder setting, read down on the chart from ratio 6 to the line extending from 1/2" work height above center; note diamond holder 15/32 above center. See Sketch No. 15.



Sketch No 15

Truing The Regulating Wheel: Infeed Work

Angle of inclination: Since the work does not traverse between the wheels, there is very little angle required. An angle between 0° and 1/4° is recommended to hold the work against the end-stop during grinding.

Table of Thrufeed Work Traverse Rates
Inches Per Minute

The rate at which the work feeds past the grinding wheel on thrufeed jobs depends upon the diameter, speed of rotation, and angle of inclination of the regulating wheel. the following table gives the approximate theoretical work feed rates in inches per minute for all combinations of these three variables.

Reg. Wheel Angle	Reg. Wheel Diam.	Regulating Wheel Speeds, R.P.M.										
		10 r.p.m.	15 r.p.m.	20 r.p.m.	25 r.p.m.	30 r.p.m.	40 r.p.m.	50 r.p.m.	70 r.p.m.	90 r.p.m.	125 r.p.m.	150 r.p.m.
1°	8.0"	4.4	6.6	8.8	11.0	13.2	17.5	21.9	30.7	39.5	54.8	70.2
	8.5	4.7	7.0	9.3	11.6	14.0	18.6	23.3	32.6	41.9	58.2	74.6
	9.0	4.9	7.4	9.9	12.3	14.8	19.7	24.7	34.5	44.4	61.7	78.9
	9.5	5.2	7.8	10.4	13.0	15.6	20.8	26.0	36.5	46.9	65.1	83.3
	10.0	5.5	8.2	11.0	13.7	16.4	21.9	27.4	38.4	49.3	68.5	87.7
	10.5	5.8	8.6	11.5	14.4	17.3	23.0	28.8	40.3	51.8	72.0	92.1
	11.0	6.0	9.0	12.1	15.1	18.1	24.1	30.2	42.2	54.3	75.4	96.5
	11.5	6.3	9.5	12.6	15.8	18.9	25.2	31.5	44.1	56.7	78.8	100.9
	12.0	6.6	9.9	13.2	16.4	19.7	26.3	32.9	46.0	59.2	82.2	105.3
	12.5	6.9	10.3	13.7	17.1	20.5	27.4	34.2	47.9	61.6	85.6	109.7
	13.0	7.1	10.7	14.3	17.8	21.3	28.5	35.6	49.8	64.1	89.0	114.1
	13.5	7.4	11.1	14.8	18.5	22.1	29.6	36.9	51.7	66.5	92.4	118.5
	14.0	7.6	11.5	15.4	19.2	22.9	30.7	38.3	53.6	69.0	95.8	122.9
2°	8.0"	8.8	13.2	17.5	21.9	26.3	35.1	43.9	61.4	78.9	109.6	140.3
	8.5	9.3	14.0	18.6	23.3	28.0	37.3	46.6	65.2	83.9	116.5	149.1
	9.0	9.9	14.8	19.7	24.7	29.6	39.5	49.3	69.1	88.8	123.3	157.9
	9.5	10.4	15.6	20.8	26.0	31.2	41.7	52.1	72.9	93.7	130.2	166.7
	10.0	11.0	16.4	21.9	27.4	32.9	43.9	54.8	76.7	98.7	137.1	175.4
	10.5	11.5	17.3	23.0	28.8	34.5	46.0	57.6	80.6	103.6	143.9	184.2
	11.0	12.1	18.1	24.1	30.2	36.2	48.2	60.3	84.4	108.5	150.8	193.0
	11.5	12.6	18.9	25.2	31.5	37.8	50.4	63.0	88.3	113.5	157.6	201.7
	12.0	13.2	19.7	26.3	32.9	39.5	52.6	65.8	92.1	118.4	164.5	210.5
	12.5	13.7	20.5	27.4	33.2	41.1	54.8	68.5	96.0	123.4	171.3	219.2
	13.0	14.3	21.3	28.5	33.6	42.8	57.0	71;3	99.8	128.3	174.2	228.5
	13.5	14.8	22.1	29.6	33.9	44.4	59.2	74.0	103.7	133.3	177.0	236.7
	14.0	15.4	22.9	30.7	34.3	46.1	61.4	76.8	107.5	138.2	183.9	245.5
3°	8.0"	13.2	19.7	26.3	32.9	39.5	52.6	65.8	92.1	118.4	164.4	210.5
	8.5	14.0	21.0	28.0	34.9	41.9	55.9	69.9	97.8	125.8	174.7	223.6
	9.0	14.8	22.2	29.6	37.0	44.4	59.2	74.0	103.6	133.2	185.0	236.8
	9.5	15.6	23.4	31.2	39.1	46.9	62.5	78.1	109.3	140.6	195.3	249.9
	10.0	16.4	24.7	32.9	41.1	49.3	65.8	82.2	115.1	148.0	205.5	263.1
	10.5	17.3	25.9	34.5	43.2	51.8	69.1	86.3	120.9	155.4	215.8	276.2
	11.0	18.1	27.1	36.2	45.2	54.3	72.3	90.4	126.6	162.8	226.1	289.4
	11.5	18.9	28.4	37.8	47.3	56.7	75.6	94.5	132.4	170.2	236.4	302.6
	12.0	19.7	29.6	39.5	49 3	59.2	78.9	98.7	138.1	177.6	246.6	315.7
	12.5	20.5	30.9	41.1	51.4	61.6	82.2	102.8	143.9	185.0	256.9	328.8
	13.0	21.3	32.1	42.8	53.4	64.1	85.5	106.9	149.6	192.4	267.2	341.9
	13.5	22.1	33.4	44.4	55.5	66.5	88.8	111.0	155.4	199.8	277.5	355.0
	14.0	22.9	34.6	46.1	57.5	69.0	92.1	115.1	161.1	207.2	287.8	368.1

Table of Thrufeed Work Traverse Rates (cont.)

Reg. Wheel Angle	Reg. Wheel Diam.	Regulating Wheel Speeds, R.P.M.										
		10 r.p.m.	15 r.p.m.	20 r.p.m.	25 r.p.m.	30 r.p.m.	40 r.p.m.	50 r.p.m.	70 r.p.m.	90 r.p.m.	125 r.p.m.	150 r.p.m.
4°	8.0"	17.5	26.3	35.1	43.8	52.6	70.1	87.7	122.7	157.8	219.2	280.5
	8.5	18.6	27.9	37.3	46.6	55.9	74.5	93 1	130.4	167.7	232.9	298.1
	9.0	19.7	29.6	39.4	49.3	59.2	78.9	98.6	138.1	177.5	246.6	315.6
	9.5	20.8	31.2	41.6	52.1	62.5	83.3	104.1	145.7	187.4	260.3	333.1
	10.0	21.9	32.9	43.8	54.8	65.7	87.7	109.6	153.4	197.2	273.9	350.7
	10.5	23.0	34.5	46.0	57.5	69.0	92.0	115.1	161.1	207.1	287.6	368.2
	11.0	24.1	36.2	48.2	60.3	72.3	96.4	120.5	168 8	217.0	301.3	385.7
	11.5	25.2	37.8	50.4	63.0	75.6	100.8	126.0	176.4	226.8	315.0	403.3
	12 0	26.3	39.4	52.6	67.7	78.9	105.2	131.5	184.1	236.7	328.7	420.8
	12.5	27.4	41.0	54.8	68.5	82.2	109.6	136.9	191.7	246.5	342.4	438.4
	13.0	28.5	42.5	57 0	71.3	85.5	114.0	142.4	199.4	256.4	356.1	456.0
	13 5	29.6	44 2	59 2	74 1	88.8	118.4	147.8	207.0	266 2	369.8	473.6
	14 0	30.7	45.8	61.4	76.9	92.1	122.8	153.3	214 7	276.1	383.5	491.2
5°	8.0"	21.9	32.9	43.8	54.8	65.7	87.6	109.5	153.3	197.2	273.8	350.5
	8.5	23 3	34.9	46.5	58.2	69.8	93.1	116.4	162.9	209.5	290.9	372.4
	9.0	24.6	37.0	49.3	61.6	73.9	98.6	123.2	172.5	221.8	308.0	394.3
	9.5	26.0	39.0	52.0	65.0	78.0	104.1	130.1	182.1	234.1	325.2	416.2
	10.0	27.4	41.1	54.8	68.5	82.1	109.5	136.9	191.7	246.4	342.3	438.1
	10.5	28.8	43.1	57.5	71.9	86.3	115.0	143.8	201.3	258.8	359.4	460.0
	11.0	30.1	45.2	60.2	75.3	90.4	120.5	150.6	210.8	271.1	376.5	481.9
	11.5	31.5	47.2	63.0	78.7	94.5	126.0	157.4	220.4	283.4	393.6	503.8
	12.0	32.9	49.3	65.7	82.1	98.6	131.4	164.3	230.0	295.7	410.7	525.7
	12.5	34.3	51.3	68.5	85.5	102.7	136.9	171.2	239.6	308.0	427.8	547.6
	13.0	35.7	53.4	71.2	88.9	106.8	142.4	178.1	249.2	320.3	444.9	560.5
	13.5	37.1	55.4	74.0	92.3	110.9	147.9	184.0	258.8	332.6	462.0	591.4
	14.0	38.5	57.5	76.7	95.7	115.0	153.4	191.9	268.4	344.9	471.9	613 3
6°	8.0"	26.3	39.4	52.5	65.7	78.8	105.1	131.4	183.9	236.4	328.4	420 3
	8.5	27.9	41.9	55.8	69.8	83.7	111.7	139.6	195.4	251.2	348.9	446.6
	9 0	29.6	44.3	59.1	73 9	88 7	118 2	147.8	206.9	266.0	369.4	472.9
	9.5	31.2	46.8	62 4	78.0	93.6	124 8	156.0	218.4	280.8	390.0	499.2
	10 0	32 8	49.3	65 7	82.1	98.5	131.4	164.2	229.9	295.6	410.5	525.4
	10 5	34 5	51.7	69 0	86 2	103.4	137.9	172.4	241.4	310 3	431.0	551.7
	11.0	36 1	54 2	72.2	90.3	108.4	144.5	180.6	252.9	325.1	451.5	578.0
	11.5	37.8	56.6	75.5	94.4	113 3	151.1	188 8	264.4	339.9	472.1	604.2
	12.0	39.4	59.1	78 8	98 5	118 2	157.6	197.0	275.8	354.7	492.6	630.5
	12.5	41.0	61.6	82.1	102.6	123.1	164.3	205.2	287.4	369.5	513.1	656.8
	13 0	42.6	64.1	85 4	106.7	128.0	170.9	213 4	298.9	384.3	533.6	683.1
	13.5	44.2	66.6	88.7	110.8	132.9	177.5	221.6	310.4	399 1	554.1	709 4
	14 0	45.8	69.1	92.0	114.9	137.8	184 1	229.8	321 9	413.9	574.6	735 7
7	8 0"	30 6	45 9	61 3	76.6	91.9	122.5	153 1	214 4	275.7	382.9	490 1
	8 5	32.5	48.8	65.1	81.4	97.6	130 2	162.7	227.8	292.9	406.8	520 7
	9 0	34 5	51 7	68 9	86 1	103 4	137 8	172.3	241 2	310.1	430.7	551 3
	9 5	36 4	54 6	72.7	90 9	109 1	145 5	181.9	254 6	327.4	454.7	582 0
	10.0	38 3	57.4	76 6	95 7	114 9	153 1	191.4	268 0	344 6	478.6	612.6
	10.5	40.2	60 3	80 4	100.5	120 6	160.8	201.0	281.4	361.8	502.5	643 2
	11.0	42 1	63.2	84.2	105.3	126.3	168 5	210 6	294.8	379 0	526.4	673.8
	11 5	44 0	66 0	88 1	110 1	132.1	176 1	220.1	308 2	396.3	550 4	704.5
	12 0	45 9	68 9	91 9	114.9	137 8	183 8	229 7	321 6	413 5	574.3	735.1
	12 5	47.8	71 8	95 7	119.7	143 5	191.5	239.3	335 0	430 7	598.2	765 7
	13 0	49 7	74.7	99 5	124 5	149 2	199.2	248 9	348 4	447 9	622.1	796.3

Typical Centerless Applications

Selection of traverse rates for thrufeed work depends upon so many factors that it is not practical to compile exact tables for all the conditions which may be encountered. Perhaps the reason will be more apparent if we tabulate some of these factors: work material (including physical characteristics), stock removal, accuracy standards, blade material, type of grinding wheel, finish desired, diameter of part, weight of part, coolant available, and physical condition of machine. Practically every job must be considered on its own merits. A good practice is to keep complete job records and use it as a guide in setting up duplicate or similar jobs. A few examples are given here to provide a starting point in selecting the correct traverse rate. All of them have been checked by time studies and represent actual job shop practice. Under high volume production conditions, the use of larger machines with higher horsepowers and wider wheels could be easily justified to reduce the number of operations.

PISTON PIN

Size — 7/8" diameter x 3 1/16" long.
Material — Hardened steel.
Stock Removal — .015" in four roughing and two finishing cuts.
Finish — High grade commercial.
Wheel — 97A-601-J6-VRW.
Traverse Rate — 12 feet per minute per cut.
Machine — 220-8 Centerless.

CHAIN ROLLER PIN

Size — 5/32" diameter x 7/16" long.
Material — Hardened steel.
Stock Removal — .005" to .008", one cut.
Finish — High grade commercial.
Wheel — 97A-601-M4-VRW.
Traverse Rate — 7 feet per minute per cut.
Machine — 220-8 Centerless.

STEEL ROD

Size — 5/8" diameter x 12" long.
Material — Soft steel.
Stock Removal — .010" to .015", three cuts.
Finish — Commercial.
Wheel — 97A-601-J6-VRW.
Traverse Rate — 7 feet per minute per cut.
Machine — 220-8 Centerless.

PISTON

Size — 3 3/16" diameter x 4" long.
Material — Cast iron.
Stock Removal — .005" three cuts.
Finish — Good commercial.
Wheel — 6C-46-K6-VSC.
Traverse Rate — 5 feet per minute per cut.
Machine — 325-12 Centerless.

Add "E" to bond symbol of wheel speed is greater than 6500 SFPM vitrified and 9500 resin.

FIN-TECH Finishing Technologies

This fine grit product is available in grit sizes ranging from 220-1200. These wheels will produce finishes in the 2 - 4 micro inch Ra range.

FIN-TECH Grinding Wheels for cylindrical and centerless grinding in thrufeed and plunge cut operations offer many technical and economical advantages.

These FIN-TECH products are well suited and designed for the grinding of:

- Struts
- Rods, Piston Pins
- Needles, Rollers
- Roll Grinding
- Razor Blades
- Hypodermic Needles

Thrufeed Grinding

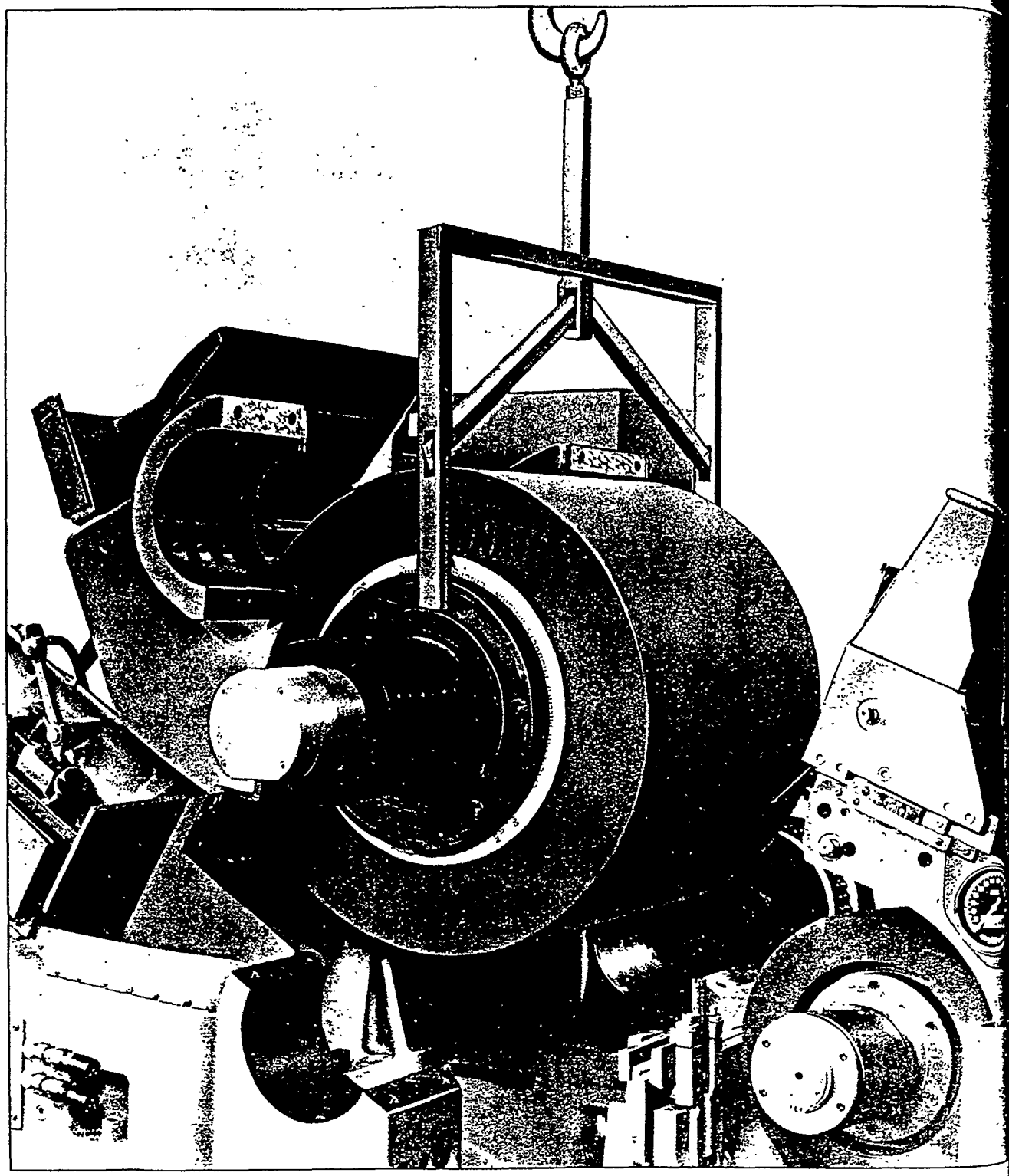
- Increase of thrufeed speed in conjunction with maximum rate of metal removal.
- Reduction of dressing time.
- Superior surface quality.
- Very fine surface finishes produced 2-4 micro inch Ra.
- Very consistant surface finishes from .3-.6 micrometer Rz.

Plunge Cut Grinding

- Excellent profile stability.
- Good cutting characteristics which increase productivity.

FIN-TECH Availability

	Resin Bond *Bond Designator: BFG*	Vitrified Bond *Bond Designator: VGF*
Diameter:	5.9 - 43.3 in. 150 - 1100mm	Max. 24 in. Max. 610mm
Thickness:	.98 - 11 8 in. 25 - 300mm	Max. 4.7 in. Max. 120mm
Grit Sizes:	220 - 1200	220 - 600
Structure:	7 - 18	7 - 12



MIL 000101

Trouble Shooting

A. Burn Marks On Workpiece

1. Insufficient coolant
2. Dull or flat diamond
3. Wheel too hard
4. Cutting on trailing edge of the wheel
5. Grinding wheel dressed with diamond traverse too slow.
6. Too heavy stock removal

B. Chatter

1. Work too high above center
2. Wheel out of balance
3. Blade angle too steep (30° standard)
4. Blade too thin or warped
5. Machine leveling screws not adjusted for even torque when machine is finally leveled
6. Glazed wheel caused by dull diamond, wheel too hard, grit size too fine or dressing rate too slow
7. Outside "Floor Harmonics"
8. Motors out of balance
9. Grinding wheel mount fits loosely on spindle
10. Stock removal too heavy
11. Blade not properly clamped
12. Blade being used too long for width of wheel

C. Dull Diamond — Grinding Wheel Truing Attachment

1. Diamond nib not turned periodically
2. Excessive infeed of diamond (should not take more than 0.001" depth of cut under normal conditions)

D. Erratic Sizing

1. Gibs not properly adjusted on upper and lower slides
2. Wear in infeed screw and nut
3. Infeed lever not held tight (for thrufeed work)
4. Soft wheel
5. Insufficient lubrication on lower slides causing slides to hang or jump (infeed)
6. Improper tension on backlash spring
7. Loose work support blade
8. Parts overheating during cut, due to improper wheel or insufficient coolant
9. Regulating wheel camming
10. Work improperly rough ground

E. Feed Lines

1. Grinding wheel not relieved on exit side
2. Work guides not properly set
3. On long bar fixtures — excessive pressure on workpiece by roller hold-down

F. Finish

1. Improper wheel grade
2. Dirty or insufficient coolant
3. Setup not correct
4. Diamond dressing traverse rate too fast
5. Erratic movement of truing attachments
6. Pick-up on blade
7. Blade not tight in work rest
8. Blade angle too steep
9. Unbalanced wheel
10. Loose, cracked or dull diamond
11. Oil on face of wheel
12. Regulating wheel not tight on its mount
13. Work too high above center
14. Regulating wheel SFM excessive

G. Fish Tails (Scratches)

1. Dirty coolant
2. Loose grit in wheel

H. Grinding Wheel

1. Too hard
   a. May cause burn marks
   b. Can cause squeal because it is not free cutting
   c. Glazing may occur on wheel face
   d. Soft materials may "load" wheel
   e. Often produce chatter on workpiece
   f. Sizing trouble, due to no spark out
   g. May cause heat checks or cracks
2. Too soft
   a. Sizing trouble, because wheel breaks down rapidly.
   b. Chatter may develop
   c. Rough finish

I. Height Above Center of Workpiece

1. If too high, chatter can develop
2. Optimum rounding action will not occur if center height is too low
3. Three-point out-of-roundness is a good sign of low center

J. Intermittent Cut

1. Grinding wheel not correctly trued
2. Regulating wheel "camming"
3. Warped workpiece

K. Jumpy Truing Device

1. Air in hydraulic lines
2. Slides not lubricated properly
3. Gib adjusted improperly

tions when needed. The harder grades are used when the regulating wheels must be very thin and the general-purpose grade deflects under the pressure of the grind. Harder grades also offer some advantage when work must be ground to very close tolerances, and when there is excessive regulating wheel wear due to the design of the work when grinding two or more diameters and one is much larger than the other. The difference in sfpm causes one of the diameters to slip or skid in contact with the wheel. The general-purpose grade gives a better drive or braking action and will resist spinning more than the finer, harder wheels on average work. The average starting speed of the regulating wheel is from 22 to 39 rpm, and for general work the angle of inclination of 3° is recommended as a starting point. However, both the angle and wheel speed can be changed to suit specific conditions. The steeper the angle, the faster the traverse rate. The flatter the angle, the slower the traverse rate.The wheel speed also affects the traverse rate. The faster the wheel speed, the faster the traverse rate, and conversely, the slower the wheel speed, the slower the traverse rate. For work that is warped from hardening or machining, the best straightening effect can be obtained by using a high traverse rate or by increasing the angle of the regulating wheel. For work that is straight, but out-of-round, a faster rounding-up action can be obtained by using a higher regulating wheel speed and a flatter angle. This does not necessarily mean less production from the machine, because increasing the wheel rpm and reducing the angle of the regulating wheel could give approximately the same traverse rate.

Truing The Regulating Wheel: Thrufeed Work

The regulating wheel must be trued to a special shape so that the work, while passing between the wheels, makes a straight-line contact with the wheel face. Four factors must be considered to set the truing unit to form this shape:

1. Angle of inclination of the regulating wheel.
2. Location of the center of the work with respect to the centerline of the grinding and regulating wheels.
3. The angle to which the regulating wheel truing slide is swiveled.
4. The amount the diamond holder is set over.

The first factor is fixed by the work. A general recommendation for most thrufeed setups is a positive inclination of 3° as a starting point.

The second factor is fixed by the diameter of the work. Generally, work is ground with its center above the centerline of the grinding and regulating wheels. For small work up to 1" diameter, adjust the blade to position the work one half of its diameter above the centerline of the wheels. For larger work, the above center adjustment seldom exceeds ½ inch.

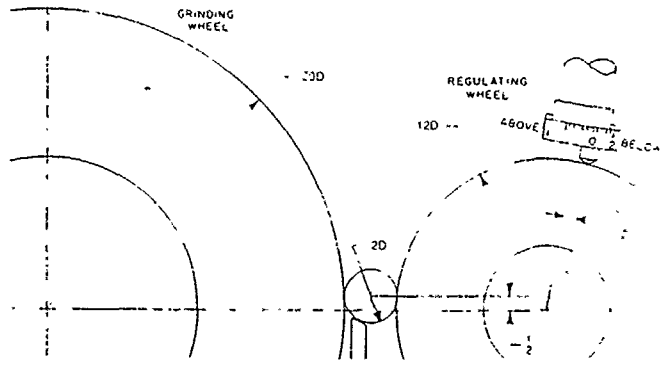
The third and fourth factors are based on the ratio of the diameter of the regulating wheel and the diameter of the workpiece. Determine the ratio by dividing the diameter of the regulating wheel by the diameter of the workpiece. After establishing this ratio, refer to the following chart to determine the correct truing angle for the truing slide and the correct diamond holder setting for dressing the special shape required on the regulating wheel.

Table Of Truing Angles And Heights Above Center For Regulating Wheel Truing

	Truing Angle Setting										
	7	6 10'	6"10'	6 20	6 25'	6 30'	6 35'	6 45'	6 50'	6 55'	6 55
	6	5 15'	5"15'	5 25'	5 30'	5"35'	5 40'	5 45'	5 55'	5 55'	5 55
WORK	5	4"20'	4 25'	4 30'	4"35'	4"40'	4 40'	4 50'	4 55	5	5
FEED	4	3 30'	3"30'	3 35'	3"40'	3'45'	3'45'	3 50'	3 55'	4	4
ANGLE*	3	2 35'	2"40'	2 40	2'45'	2'50'	2'50'	2 55'	2 55'	3	3
	2	1 45'	1'45'	1 50	1'50'	1"50'	1 55'	1 55'	2	2	2
	1	50'	50'	55	55'	55'	55'	55'	1	1	1
RATIO D/d		3	3.5	4	5	6	7	12	18	24	48
	1/8"	7/64"	7/64"	7/64	7/64"	7/64"	1/8"	1/8'	1/8	1/8	1/8
WORK	1/4"	7/32"	7/32"	7/32	15/64"	15/64"	15/64"	15/64'	1/4	1/4	1/4
HEIGHT	3/8"	21/64"	21/64'	11/32	11/32"	11/32"	23/64"	23/64'	23/64"	3/8	3/8
ABOVE	1/2"	7/16"	7/16"	29/64	29/64"	15/32"	15/32"	31/64	31/64	1/2	1/2
CENTER†	5/8"	35/64"	35/64"	9/16	37/64"	37/64"	19/32"	19/32"	29/64	5/8	5/8
	3/4"	21/32"	21/32"	43/64	11/16"	45/64"	45/64"	23/32'	47/64"	47/64	47/64
	7/8"	3/4	29/64	25/32	51/64"	13/16"	55/64"	27/32	55/64	55/64	55/64
	1"	55/64"	7/8"	29/32	59/64"	15/16"	15/16"	61/64	63/64	63/64	63/64

To use the chart, consider a setup with a 3° angle of inclination, 2 work diameter, ½" height above center, 12" diameter regulating wheel.

To determine the ratio, divide the diameter of regulating wheel by the diameter of the work (12 divided by 2 = 6 ratio). Note chart — ratio 6 — read up on the chart to the line extending from 3° — note angle to swivel truing slide is 2°50'. To determine the diamond holder setting, read down on the chart from ratio 6 to the line extending from ½" work height above center; note diamond holder 15/32 above center. See Sketch No. 15.



Sketch No 15

Truing The Regulating Wheel: Infeed Work

Angle of inclination: Since the work does not traverse between the wheels, there is very little angle required. An angle between 0° and ½° is recommended to hold the work against the end-stop during grinding.

The position of the center of the work in relation to the centerline of the wheels is the same for infeed as thrufeed. Raise the center of the work above the centerline of the wheel an amount equal to ½ the work diameter for work 1" diameter and smaller, to ½" maximum for work larger than 1".

The regulating wheel truing slide is swiveled the same amount as the angle of inclination except when truing a special shape form the profile truing cam. When truing from the cam, the slide should be set at zero.

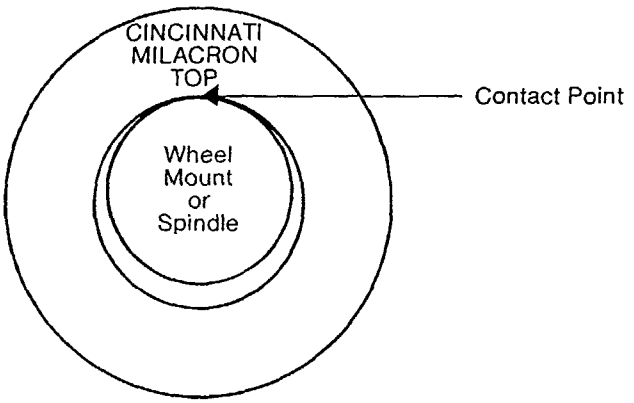
The diamond holder should be set over for infeed work the same as for thrufeed work; however, if dressing a special shape from the profile cam, the diamond holder should be set at zero.

The workpiece may be set at any height above center to obtain required roundness. With a small angle of inclination, the line of contact of the workpiece will be full at height above center. However, if the angle of inclination is increased beyond 1/4°, the full line of contact will not result and further corrections will have to be made to full line contact between the regulating wheel and workpiece.

How To Use "Top" Mark When Mounting CINCINNATI MILACRON Grinding Wheels

On-Machine Mounting

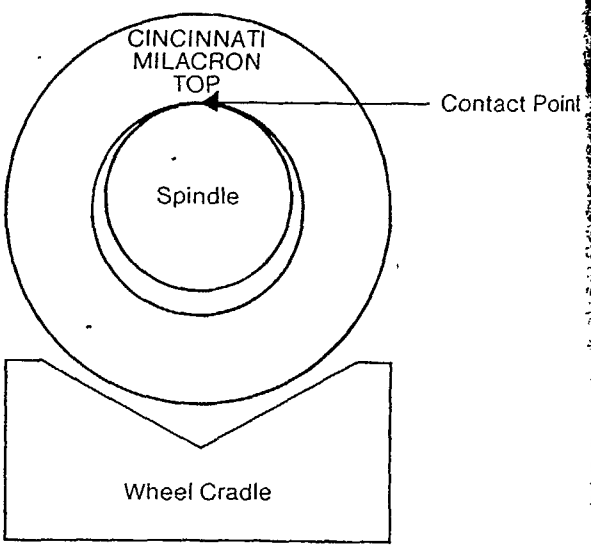
The TOP mark indicates the point of contact between wheel and spindle when the wheel's OD was trued at Cincinnati. Wheel user should mount wheel in the same way (i.e. align TOP with point of contact) to minimize OD runout and truing. Typical mountings are shown schematically below.



Off-Machine Mounting Of TWIN GRIP Wheels

Set wheel on cradle with TOP at 12 o'clock position. Place a blotter on fixed flange and insert spindle into wheel bore. Place a blotter on loose flange and mate flange with spindle; secure it with one screw, finger tight. Lift spindle-wheel assembly off cradle as shown.

Insert remaining flange screws and tighten them, in approved manner, while wheel is suspended as shown. *See photo opposite page.*



Mounting Wheels On TWIN GRIP Centerless Grinders

The Operators Hand Book has a comprehensive section on proper wheel mounting methods. Here are a few tips to make the job easier.

1. With wheels resting in cradle, install rear blotter, insert the spindle cartridge.
2. Install front blotter, flange, and bolts and snug up finger tight.
3. Raise assembly from the cradle, and tighten bolts with a torque wrench. *NOTE*: Wheel should be mounted with *top up.*
4. For wide wheel twingrips (18-20"), torque bolts to 45 foot pounds; for smaller twingrips (10-12") 35 foot pounds is sufficient.
5. Retorque the clamping flange bolts after the first 8 hours of operation.

MIL 000104

Table of Thrufeed Work Traverse Rates Inches Per Minute

The rate at which the work feeds past the grinding wheel on thrufeed jobs depends upon the diameter, speed of rotation, and angle of inclination of the regulating wheel. the following table gives the approximate theoretical work feed rates in inches per minute for all combinations of these three variables.

Reg. Wheel Angle	Reg. Wheel Diam.	Regulating Wheel Speeds, R.P.M.										
		10 r.p.m.	15 r.p.m.	20 r.p.m.	25 r.p.m.	30 r.p.m.	40 r.p.m.	50 r.p.m.	70 r.p.m.	90 r.p.m.	125 r.p.m.	150 r.p.m.
1°	8.0"	4.4	6.6	8.8	11.0	13.2	17.5	21.9	30.7	39.5	54.8	70.2
	8.5	4.7	7.0	9.3	11.6	14.0	18.6	23.3	32.6	41.9	58.2	74.6
	9.0	4.9	7.4	9.9	12.3	14.8	19.7	24.7	34.5	44.4	61.7	78.9
	9.5	5.2	7.8	10.4	13.0	15.6	20.8	26.0	36.5	46.9	65.1	83.3
	10.0	5.5	8.2	11.0	13.7	16.4	21.9	27.4	38.4	49.3	68.5	87.7
	10.5	5.8	8.6	11.5	14.4	17.3	23.0	28.8	40.3	51.8	72.0	92.1
	11.0	6.0	9.0	12.1	15.1	18.1	24.1	30.2	42.2	54.3	75.4	96.5
	11.5	6.3	9.5	12.6	15.8	18.9	25.2	31.5	44.1	56.7	78.8	100.9
	12.0	6.6	9.9	13.2	16.4	19.7	26.3	32.9	46.0	59.2	82.2	105.3
	12.5	6.9	10.3	13.7	17.1	20.5	27.4	34.2	47.9	61.6	85.6	109.7
	13.0	7.1	10.7	14.3	17.8	21.3	28.5	35.6	49.8	64.1	89.0	114.1
	13.5	7.4	11.1	14.8	18.5	22.1	29.6	36.9	51.7	66.5	92.4	118.5
	14.0	7.6	11.5	15.4	19.2	22.9	30.7	38.3	53.6	69.0	95.8	122.9
2°	8.0"	8.8	13.2	17.5	21.9	26.3	35.1	43.9	61.4	78.9	109.6	140.3
	8.5	9.3	14.0	18.6	23.3	28.0	37.3	46.6	65.2	83.9	116.5	149.1
	9.0	9.9	14.8	19.7	24.7	29.6	39.5	49.3	69.1	88.8	123.3	157.9
	9.5	10.4	15.6	20.8	26.0	31.2	41.7	52.1	72.9	93.7	130.2	166.7
	10.0	11.0	16.4	21.9	27.4	32.9	43.9	54.8	76.7	98.7	137.1	175.4
	10.5	11.5	17.3	23.0	28.8	34.5	46.0	57.6	80.6	103.6	143.9	184.2
	11.0	12.1	18.1	24.1	30.2	36.2	48.2	60.3	84.4	108.5	150.8	193.0
	11.5	12.6	18.9	25.2	31.5	37.8	50.4	63.0	88.3	113.5	157.6	201.7
	12.0	13.2	19.7	26.3	32.9	39.5	52.6	65.8	92.1	118.4	164.5	210.5
	12.5	13.7	20.5	27.4	33.2	41.1	54.8	68.5	96.0	123.4	171.3	219.2
	13.0	14.3	21.3	28.5	33.6	42.8	57.0	71;3	99.8	128.3	174.2	228.5
	13.5	14.8	22.1	29.6	33.9	44.4	59.2	74.0	103.7	133.3	177.0	236.7
	14.0	15.4	22.9	30.7	34.3	46.1	61.4	76.8	107.5	138.2	183.9	245.5
3°	8.0"	13.2	19.7	26.3	32.9	39.5	52.6	65.8	92.1	118.4	164.4	210.5
	8.5	14.0	21.0	28.0	34.9	41.9	55.9	69.9	97.8	125.8	174.7	223.6
	9.0	14.8	22.2	29.6	37.0	44.4	59.2	74.0	103.6	133.2	185.0	236.8
	9.5	15.6	23.4	31.2	39.1	46.9	62.5	78.1	109.3	140.6	195.3	249.9
	10.0	16.4	24.7	32.9	41.1	49.3	65.8	82.2	115.1	148.0	205.5	263.1
	10.5	17.3	25.9	34.5	43.2	51.8	69.1	86.3	120.9	155.4	215.8	276.2
	11.0	18.1	27.1	36.2	45.2	54.3	72.3	90.4	126.6	162.8	226.1	289.4
	11.5	18.9	28.4	37.8	47.3	56.7	75.6	94.5	132.4	170.2	236.4	302.6
	12.0	19.7	29.6	39.5	49.3	59.2	78.9	98.7	138.1	177.6	246.6	315.7
	12.5	20.5	30.9	41.1	51.4	61.6	82.2	102.8	143.9	185.0	256.9	328.8
	13.0	21.3	32.1	42.8	53.4	64.1	85.5	106.9	149.6	192.4	267.2	341.9
	13.5	22.1	33.4	44.4	55.5	66.5	88.8	111.0	155.4	199.8	277.5	355.0
	14.0	22.9	34.6	46.1	57.5	69.0	92.1	115.1	161.1	207.2	287.8	368.1

MIL 000105

Table of Thrufeed Work Traverse Rates (cont.)

Reg. Wheel Angle	Reg. Wheel Diam.	Regulating Wheel Speeds, R.P.M.										
		10 r.p.m.	15 r.p.m.	20 r.p.m.	25 r.p.m.	30 r.p.m.	40 r.p.m.	50 r.p.m.	70 r.p.m.	90 r.p.m.	125 r.p.m.	150 r.p.m.
4°	8.0"	17.5	26.3	35.1	43.8	52.6	70.1	87.7	122.7	157.8	219.2	280.5
	8.5	18.6	27.9	37.3	46.6	55.9	74.5	93.1	130.4	167.7	232.9	298.1
	9.0	19.7	29.6	39.4	49.3	59.2	78.9	98.6	138.1	177.5	246.6	315.6
	9.5	20.8	31.2	41.6	52.1	62.5	83.3	104.1	145.7	187.4	260.3	333.1
	10.0	21.9	32.9	43.8	54.8	65.7	87.7	109.6	153.4	197.2	273.9	350.7
	10.5	23 0	34.5	46.0	57.5	69.0	92.0	115.1	161.1	207.1	287.6	368.2
	11.0	24.1	36.2	48.2	60.3	72.3	96.4	120.5	168.8	217.0	301.3	385.7
	11.5	25.2	37.8	50.4	63.0	75.6	100.8	126.0	176.4	226.8	315.0	403.3
	12.0	26.3	39.4	52.6	67.7	78.9	105.2	131.5	184.1	236.7	328.7	420.8
	12.5	27 4	41 0	54.8	68.5	82.2	109.6	136.9	191.7	246.5	342.4	438.4
	13.0	28.5	42.5	57.0	71.3	85.5	114.0	142.4	199.4	256.4	356.1	456.0
	13.5	29.6	44.2	59.2	74.1	88.8	118.4	147.8	207.0	266.2	369.8	473.6
	14.0	30.7	45.8	61.4	76.9	92.1	122.8	153.3	214.7	276.1	383.5	491.2
5°	8.0"	21.9	32.9	43 8	54.8	65.7	87.6	109.5	153.3	197.2	273.8	350.5
	8.5	23.3	34.9	46.5	58.2	69.8	93.1	116.4	162.9	209.5	290.9	372.4
	9 0	24.6	37.0	49.3	61.6	73.9	98.6	123.2	172.5	221.8	308.0	394.3
	9.5	26.0	39.0	52.0	65.0	78.0	104.1	130.1	182.1	234.1	325.2	416.2
	10.0	27.4	41.1	54.8	68.5	82.1	109.5	136.9	191.7	246.4	342.3	438.1
	10.5	28.8	43.1	57.5	71.9	86.3	115.0	143.8	201.3	258.8	359.4	460.0
	11.0	30.1	45.2	60.2	75.3	90.4	120.5	150.6	210.8	271.1	376.5	481.9
	11.5	31.5	47.2	63.0	78.7	94.5	126.0	157.4	220.4	283.4	393.6	503.8
	12.0	32.9	49.3	65.7	82.1	98.6	131.4	164.3	230.0	295.7	410.7	525.7
	12.5	34.3	51.3	68.5	85.5	102.7	136.9	171.2	239.6	308.0	427.8	547.6
	13.0	35.7	53.4	71.2	88.9	106.8	142.4	178 1	249.2	320.3	444.9	560.5
	13.5	37.1	55.4	74.0	92.3	110.9	147.9	184.0	258.8	332.6	462.0	591.4
	14.0	38.5	57.5	76.7	95.7	115.0	153.4	191.9	268.4	344.9	471.9	613.3
6°	8.0"	26.3	39.4	52.5	65.7	78.8	105.1	131.4	183.9	236.4	328.4	420.3
	8.5	27.9	41.9	55.8	69.8	83.7	111.7	139.6	195.4	251.2	348.9	446.6
	9.0	29.6	44.3	59.1	73.9	88.7	118 2	147.8	206.9	266.0	369.4	472.9
	9.5	31.2	46.8	62.4	78.0	93.6	124.8	156.0	218.4	280.8	390.0	499.2
	10.0	32.8	49.3	65.7	82.1	98.5	131.4	164.2	229.9	295.6	410.5	525.4
	10.5	34 5	51.7	69.0	86.2	103.4	137.9	172.4	241.4	310 3	431.0	551.7
	11.0	36 1	54.2	72.2	90.3	108 4	144.5	180.6	252.9	325.1	451.5	578.0
	11.5	37.8	56.6	75.5	94.4	113.3	151.1	188.8	264 4	339.9	472.1	604.2
	12.0	39.4	59.1	78.8	98.5	118.2	157.6	197.0	275 8	354.7	492.6	630.5
	12.5	41 0	61.6	82.1	102.6	123.1	164.3	205.2	287.4	369.5	513.1	656.8
	13 0	42.6	64 1	85.4	106.7	128 0	170.9	213 4	298.9	384.3	533.6	683.1
	13.5	44.2	66.6	88.7	110.8	132.9	177.5	221 6	310.4	399.1	554.1	709.4
	14.0	45.8	69 1	92.0	114.9	137.8	184.1	229.8	321.9	413.9	574.6	735.7
7	8 0"	30 6	45 9	61.3	76.6	91.9	122.5	153 1	214.4	275.7	382.9	490.1
	8 5	32 5	48 8	65 1	81 4	97 6	130.2	162 7	227.8	292.9	406.8	520.7
	9.0	34 5	51 7	68 9	86.1	103.4	137.8	172.3	241 2	310.1	430.7	551.3
	9.5	36.4	54.6	72.7	90.9	109.1	145.5	181.9	254 6	327.4	454.7	582.0
	10.0	38.3	57 4	76.6	95.7	114.9	153.1	191 4	268.0	344.6	478.6	612.6
	10 5	40 2	60 3	80.4	100.5	120 6	160.8	201 0	281 4	361.8	502.5	643.2
	11 0	42 1	63 2	84 2	105.3	126.3	168.5	210 6	294 8	379 0	526 4	673.8
	11 5	44 0	66.0	88.1	110.1	132 1	176 1	220 1	308.2	396.3	550.4	704.5
	12.0	45 9	68 9	91 9	114 9	137.8	183.8	229 7	321 6	413.5	574.3	735 1
	12.5	47 8	71.8	95 7	119.7	143.5	191.5	239 3	335.0	430.7	598.2-	765.7
	13 0	49.7	74.7	99.5	124.5	149.2	199.2	248 9	348.4	447 9	622.1	796.3

MIL 000106

Typical Centerless Applications

Selection of traverse rates for thrufeed work depends upon so many factors that it is not practical to compile exact tables for all the conditions which may be encountered. Perhaps the reason will be more apparent if we tabulate some of these factors: work material (including physical characteristics), stock removal, accuracy standards, blade material, type of grinding wheel, finish desired, diameter of part, weight of part, coolant available, and physical condition of machine. Practically every job must be considered on its own merits. A good practice is to keep complete job records and use it as a guide in setting up duplicate or similar jobs. A few examples are given here to provide a starting point in selecting the correct traverse rate. All of them have been checked by time studies and represent actual job shop practice. Under high volume production conditions, the use of larger machines with higher horsepowers and wider wheels could be easily justified to reduce the number of operations.

PISTON PIN

Size — $^{7}/_{8}$" diameter x $3^{1}/_{16}$" long.
Material — Hardened steel.
Stock Removal — .015" in four roughing and two finishing cuts.
Finish — High grade commercial.
Wheel — 97A-601-J6-VRW.
Traverse Rate — 12 feet per minute per cut.
Machine — 220-8 Centerless.

CHAIN ROLLER PIN

Size — $^{5}/_{32}$" diameter x $^{7}/_{16}$" long.
Material — Hardened steel.
Stock Removal — .005" to .008", one cut.
Finish — High grade commercial.
Wheel — 97A-601-M4-VRW.
Traverse Rate — 7 feet per minute per cut.
Machine — 220-8 Centerless.

STEEL ROD

Size — $^{5}/_{8}$" diameter x 12" long.
Material — Soft steel.
Stock Removal — .010" to .015", three cuts.
Finish — Commercial.
Wheel — 97A-601-J6-VRW.
Traverse Rate — 7 feet per minute per cut.
Machine — 220-8 Centerless.

PISTON

Size — $3^{3}/_{16}$" diameter x 4" long.
Material — Cast iron.
Stock Removal — .005" three cuts.
Finish — Good commercial.
Wheel — 6C-46-K6-VSC.
Traverse Rate — 5 feet per minute per cut.
Machine — 325-12 Centerless.

Add "E" to bond symbol of wheel speed is greater than 6500 SFPM vitrified and 9500 resin.

FIN-TECH Finishing Technologies

This fine grit product is available in grit sizes ranging from 220-1200. These wheels will produce finishes in the 2 - 4 micro inch Ra range.

FIN-TECH Grinding Wheels for cylindrical and centerless grinding in thrufeed and plunge cut operations offer many technical and economical advantages.

These FIN-TECH products are well suited and designed for the grinding of:

- Struts
- Rods, Piston Pins
- Needles, Rollers
- Roll Grinding
- Razor Blades
- Hypodermic Needles

Thrufeed Grinding

Increase of thrufeed speed in conjunction with maximum rate of metal removal.

- Reduction of dressing time.
- Superior surface quality.
- Very fine surface finishes produced 2-4 micro inch Ra.
- Very consistant surface finishes from .3-.6 micrometer Rz.

Plunge Cut Grinding

- Excellent profile stability.
- Good cutting characteristics which increase productivity.

FIN-TECH Availability

	Resin Bond *Bond Designator: BFG*	Vitrified Bond *Bond Designator: VGF*
Diameter:	5.9 - 43.3 in. 150 - 1100mm	Max. 24 in. Max. 610mm
Thickness:	.98 - 11.8 in. 25 - 300mm	Max. 4.7 in. Max. 120mm
Grit Sizes:	220 - 1200	220 - 600
Structure:	7 - 18	7 - 12

Basic Principles Of Centerless Grinding

Type of Parts

A. Parts that don't have centers, such as valve lifters, piston pins, bars, bearing rollers, bearing cups, sockets, irregular shape parts, etc.

Selection Of Wheels For Centerless Grinder Guidelines

A. Things to consider:
   1. Roughing or finishing
   2. Thrufeed or infeed
   3. Stock removal
   4. Requirements of finished part

Grading The Wheel

A. For roughing, use coarse grain and medium grade.
B. For finishing, use finer grain and harder grade.
C. For thrufeed in general, use medium grades according to stock removal.
D. For infeed, use finer grades and usually tighter structure.
E. For heavy stock removal on soft parts, use coarse resin wheel or coarse medium grade vitrified wheel.
F. For lighter stock removal of hard parts, use medium to fine grain and medium to hard wheel K-L, vitrified.
G. For medium finish, use medium grit size and grade 60K.
H. For high finish, use finer grit and medium to harder grade.

Setting Up The Machine

A. For roughing soft parts at fast rate, use 4-5° angle, 40-50 RPM, center height — variable.
B. For finishing hard parts, use slower rate, 2-3° angle, 25 - 35 RPM, same center height.

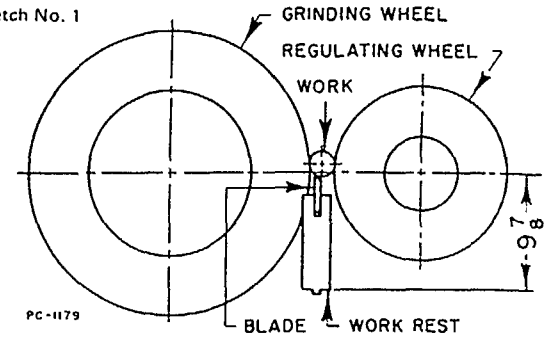
Trouble Shooting

A. Parts Spinning — usually losing regulating wheel contact, regulating wheel too fine or too hard, usually happens with small hard part during a light cut using a coolant with a lot of lubricant.
B. Out of Roundness — usually center height too low or chatter is being read as out of roundness.
C. Chatter — usually occurs when wheel is too hard, too high above center, lack of rigidity in setup.

Theory And Principles Of Centerless Grinding

The three elements of the centerless grinder are the grinding wheel, regulating wheel, and workrest (Sketch No. 1).

Sketch No. 1

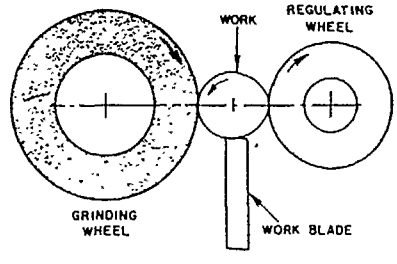


The work lies between the two wheels: a grinding wheel of the correct size to fit the machine and of specifications appropriate to the material and nature of the work; and the regulating wheel. The regulating wheel serves as both a driving wheel and a brake, rotating the work at a constant surface speed equal to that of the regulating wheel. This wheel is usually rubber bond, aluminum oxide grain, 80 grit, "R" grade. Harder grades and finer grain sizes are available for special application on very small diameter parts or for use with thin grinding wheels.

A workrest blade supports the work between the two wheels. It is adjustable for height to raise or lower the center of the work in relation to the centerline of the grinding wheel and the regulating wheel. To grind the work cylindrically, the work blade height is usually adjusted to raise the center of the work above the centerline of the wheels an amount equal to ½ the work diameter on small diameter parts, and to ½" maximum for work over 1" diameter. The distance between the grinding wheel and

Effect of out-of-round work on flat top blade, and with work on center

Sketch No. 2

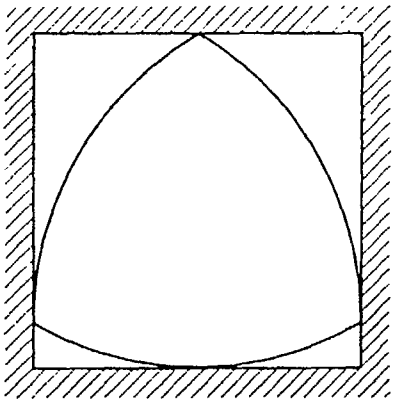


the regulating wheel controls the diameter of the work; the height of the center of the work in relation to the centerline of the wheels controls the roundness of the work. Sketch No. 2 further illustrates this phenomenon. This setup shows the center of the work in line with the center-

line of the wheels and the flat top blade. The surface of the wheels contacting the work and the flat top blade form three sides of a square. As the work is rotated, any high spot coming in contact with the regulating wheel will push the work into the grinding wheel, causing a diametrically opposite low spot. With this setup, the work will not be ground round, although it will mic or gauge perfectly. This setup creates a shape like a rounded 120° triangle (note Sketch No. 3).

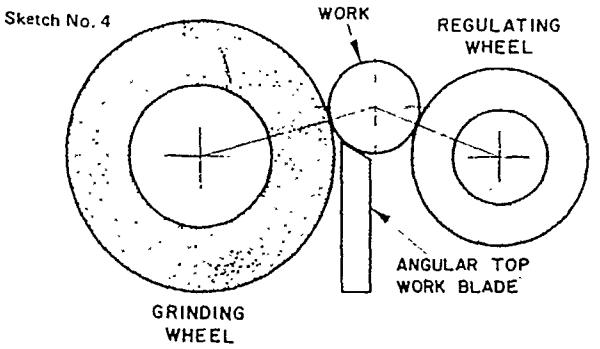
To check for this out-of-round shape, the work must be put in a 120° "V" block and rotated with an indicator in contact with the work. When checked in a 90° "V" block, with micrometers or by snap gauges, this defect in geometry will not be detected.

Exaggerated shape generated by above setup



When the center of the work is raised above the centerline of the wheels' raising the workrest blade, any high spot on the work coming in contact with the regulating wheel will push the work into the grinding wheel, creating a low spot, but not diametrically opposite. As the work is rotated, the high and low spots do not occur opposite each other as they do when the center of the work is on the centerline of the wheels and a gradual rounding up takes place. Maximum rounding action occurs when an angle top blade is used, as shown in Sketch No. 4.

Maximum corrective rounding action obtained with this basic setup

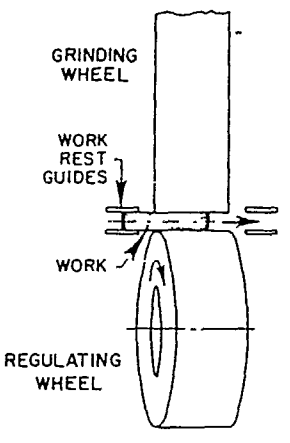


The higher the work is positioned above the centerline of the wheels, the quicker the rounding action. However, if the work is too high, chatter develops from the work being squeezed up from between the wheels or raised off the blade and dropped back on the blade rapidly, causing chatter. Since the height of the center of the work above the centerline of the wheels controls roundness, it may be necessary to set the blade extra high to grind a particular part within a specified tolerance. When this condition exists, an extra soft grade of wheel will help to prevent chatter that results when the work is too high above centerline of wheels. The soft wheel reduces the contact pressure, which reduces the tendency to lift the work from the blade.

When grinding long work such as steel bars, or tubing that is not straight, the workpiece will whip and chatter. Better results can be obtained by lowering the blade to position the center of the work below the centerline of the wheels for the first pass. Then raise the blade to put the center of work above the centerline of the wheels for additional passes to round up the work and grind to size. When grinding below the centerline of the wheels, the wheels hold the work down firmly against the blade, thus reducing the tendency of the bar to whip and chatter. If straight bars are required, they must be straightened before grinding since bent or crooked bars cannot be corrected by the centerless grinder.

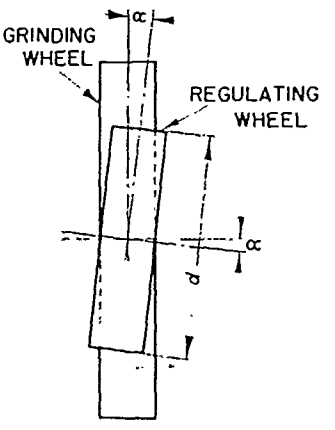
There are three general methods of centerless grinding: thrufeed, infeed, and endfeed. Thrufeed is the method whereby work is passed between the grinding wheel and the regulating wheel, and grinding takes place as the work passes from one side of the wheels to the other. Since the work passes between the wheels from side to side, only straight cylindrical work, without shoulders, can be ground thrufeed (note Sketch No. 5). The lateral movement of the work past the grinding wheel is a result of the angle of the regulating wheel (note Sketch No. 6).

Thrufeed centerless grinding (top view)



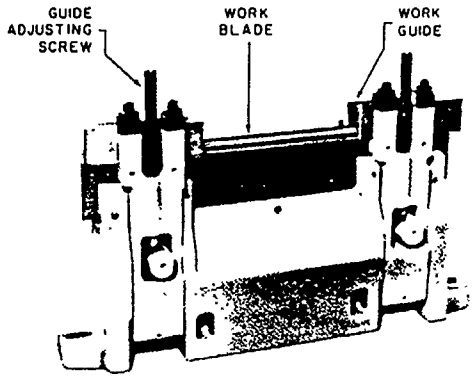
Sketch No 5

Sketch showing derivation of feed rate formula



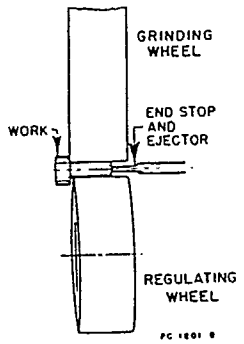
Sketch No. 6

This angle can be varied from 2° below to approximately 8° above a line relative to the axis of the grinding wheel spindle. It is often necessary to pass work between the wheels more than once to remove the stock and set the straightness, roundness, and finish required. The thrufeed workrest (note Sketch No. 7) holds the work blade and has adjustable guides at both the front and rear of the wheels to direct the work in a straight line into and from the wheels.

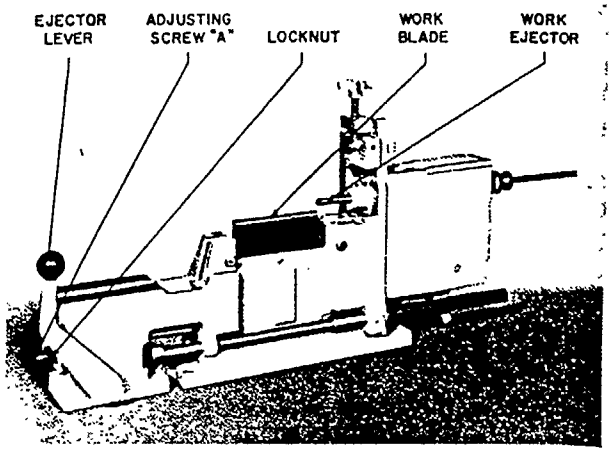


The infeed method is used when the work has a shoulder or head, when more than one diameter is ground at the same time, or when some other irregular shape is being ground. The part length that can be ground by this method is limited by the width of the grinding wheel. The wheel is dressed to match the form of the part, either by using a cluster or single-point diamond and a cam in the profile dressing attachment, or a diamond impregnated roll, or the wheel is crush dressed to shape. As the work does not traverse across the wheel face, the regulating wheel is set with only a slight angle to keep the work against the end stop. The part is laid on the work blade and regulating wheel and against the end stop, either manually or mechanically, and advanced into the grinding wheel (note Sketch No. 8 and Sketch No. 9).

Infeed centerless grinding (top view)



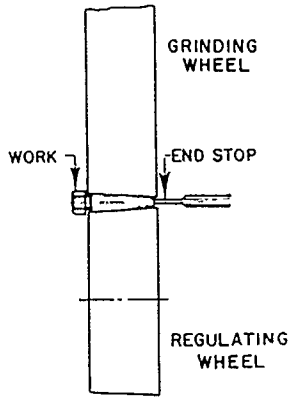
Sketch No. 8



When the work is ground to size, the regulating wheel is moved back away from the grinding wheel; either a manual or automatic ejector kicks the work out from between the wheel; and the operator places another piece in position.

The endfeed method is used on taper work only. The grinding wheel, the regulating wheel, and the work blade are set in a fixed relation to each other and the work is fed in from the front to a fixed end-stop. The taper is dressed on either the grinding wheel, the regulating wheel, or both (note Sketch No. 10).

Endfeed centerless grinding (top view)



Sketch No. 10

Work Blades

Blade material is an important consideration in obtaining good blade life between regrinds and a satisfactory finish on the workpiece. The blade can be soft bronze, cast iron, or harder alloys like stellite or sintered carbide. In general, it is advisable to start with the hardest material. Bronze, cast iron, and soft materials are used when blade pickup

occurs and cannot be controlled by other methods. Increasing the lubricity in the grinding fluid or changing to one with more lubricity reduces friction between the work and blade, and helps prevent blade pickup. Fluid application is as important as type of fluid. The work can be flooded on top but may remain dry between the work and the blade. The position of the work relative to the centerline of the wheels is another factor that affects blade pickup. The closer the center of the work is to the centerline of the wheels, the lower the pressure between the work and the blade. The higher the center of the work in relation to the centerline of the wheels, the lower the pressure between the work and the blade. A softer grade of grinding wheel will also reduce pressure on blade and help eliminate blade pickup and reduce blade wear.

Blade Angle

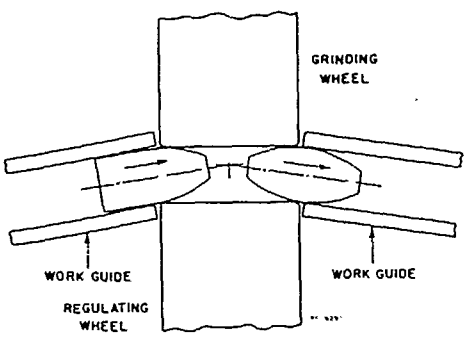
Most centerless grinding is done with an " angle top" blade. The angle of the blade should be varied to match the diameter of the work. The larger the work diameter or the longer the blade, the flatter the blade angle. The smaller diameter work requires a steeper angle. By using the steeper blade angle, more pressure is put on the regulating wheel, giving it more control of the rotating speed of the grinding wheel. However, this also increases the side pressure on the workrest blade and on narrow blades. Too steep an angle can cause the blade to deflect under the pressure, thus developing chatter. For work ½" diameter or larger, a blade angle of 20° to 30° is generally satisfactory.

Centerless Grinding Corrective Adjustments

Barrel-Shaped Parts, Thrufeed Grinding

Taper on the ends of short work (barrel shape) or taper toward the center of short bars is usually caused by improper alignment of the work guides and blade, or the regulating wheel has not been trued correctly (note Sketch No. 11).

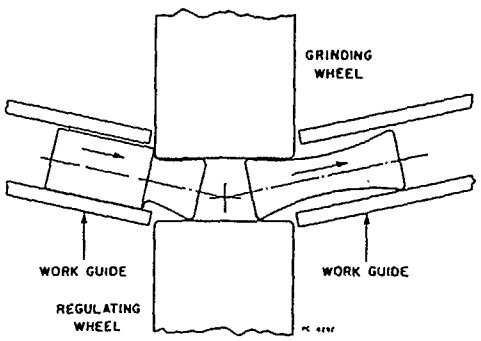
Effect of deflecting guides toward regulating wheel



Sketch No. 11

Taper on the front end of the work as it leaves the machine is caused by deflection of the work guides on the entrance side towards the regulating wheel. Taper on the rear end of the work is generally caused by the guides on the exit side of the machine. Barrel shape is usually caused by deflection of the work guides, both front and rear, toward the regulating wheel. Work guides, when deflected towards the grinding wheel, on either or both sides, have a tendency to produce work with a hollow shape (note Sketch No. 12).

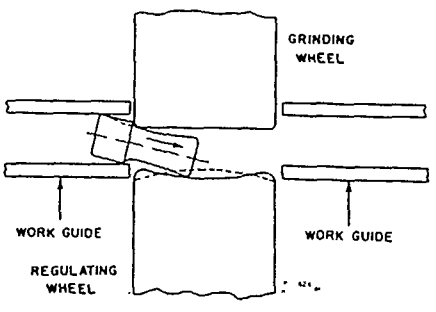
Effect of deflecting guides toward grinding wheel



Sketch No. 12

Barrel-shaped and hollow parts can also be caused by an improperly trued regulating wheel. A concave face on the regulating wheel will produce work that is small in the center, and a convex face will produce barrel-shaped work (note Sketch No. 13). A warped blade will also produce barrel-shaped work. To produce work with a true cylindrical shape, the guides and blade must be properly aligned and wheels trued correctly.

Effect of convex and concave face regulating wheel



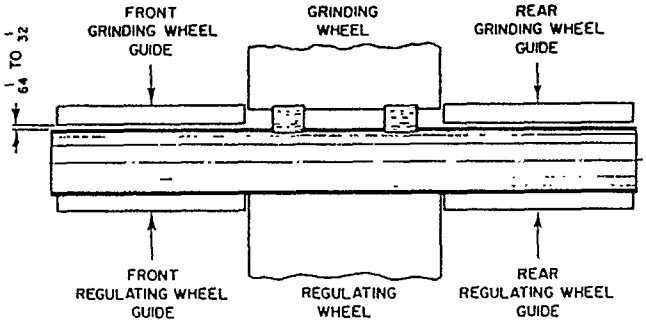
Sketch No. 13

Work Guide Adjustments For Thrufeed Work

For all thrufeed work, set the bearing surface of the workrest guides on the regulating wheel side parallel and in line with the face of the regulating wheel. To accurately set the regulating wheel guides (front and rear), use an aligning bar or other shaft that is straight within 0.0001", approximately of the same diameter as the workpiece, and as long as the width of the regulating wheel plus the length of the front and rear guides.

Set up the machine to grind the workpiece. Set the blade for height above the centerline of the wheels, set the regulating wheel housing to feed angle to be used, and true the regulating wheel. Back off the regulating wheel guides and place the aligning bar on the blade, adjust the regulating wheel to support the aligning bar, but do not allow the aligning bar to contact the grinding wheel.

Place two small wooden wedges between the grinding wheel and the bar to hold the aligning bar against the face of the regulating wheel. Bring the regulating wheel guides forward until they lightly contact the aligning bar. Use a feeler gage to determine if a full line contact is obtained between the workrest guides and the alignment bar. The workrest guides on the grinding wheel side are adjusted to 1/64" to 1/32" clearance since the work does not contact these guides. Refer to Sketch No. 14.



Sketch No. 14

Spiral Feed Lines On Work

Spiral feed lines are usually caused by the trailing edge of the grinding wheel. To prevent these marks, dress a short taper on the back edge of the wheel so the part will quit grinding approximately 1/2" from the edge of the wheel. By using a crowned cam in the dressing attachment this can be done more uniformly, and each dress will reproduce the taper without special attention from the operator. Spiral feedlines can also be generated when the grinding wheel is dressed out of parallelism to the plane of feed. To correct, reset the taper control adjustment build into the machine.

Tolerance

Work is ground in regular production to a tolerance of +0.0002 on long bars and to a total tolerance of 0.0002 on short bars. However, under ideal conditions (machines and parts in air conditioned rooms, temperature controlled coolant, etc.), tolerances as small as 25 to 50 millionths of an inch have been ground on the centerless grinder in regular production.

When grinding to extremely close tolerances, on very fine finishes which require a light cut on the finish pass, the parts may stop rotating before they are out from between the wheels, and flat spots will be ground on the parts. This usually occurs when the cut runs out before the part is clear of the grinding wheel. To help correct this problem, adjust the stock removal per pass to leave more stock on the part for the finish pass. Also, a hold-down roller or some other device can be used to hold the part against the regulating wheel to keep it turning until it is clear of the grinding wheel.

Grade of Grinding Wheel

To select a grade of grinding wheel for an operation on a centerless grinder after it has been determined which of the three general classes of work the operation falls into (thrufeed, infeed or endfeed), the following variables must be considered: material (type and whether hardened or green grind), the diameter of the part, the length of the part (if infeed, the contour or form to hold), the size of the grinding wheel, both diameter and thickness, stock removal (per pass, if thrufeed), finish required, and production per hours or parts per dress. With this information and a grinding wheel recommendation chart for centerless grinders, a trial or starting grade can be selected to grind the part. There is no established method or rule whereby the optimum grade of wheel can be selected from a chart or a known set of circumstances, because there are many uncontrollable variables that affect grinding. A grade must be tried and, from the results of the trial, the grade can be adjusted to improve the action of the grinding wheel until the desired production, finish, etc, are achieved.

Truing The Grinding Wheel

The grinding wheel may require truing for several reasons: to correct wheel imbalance, to do rough grinding, to do finish grinding, for accuracy requirements, to restore the wheel to shape, to remove glaze and prevent chatter and burning of work, or to remove load from the wheel when grinding soft material (brass, aluminum, etc.). The rate of travel of the truing tool across the wheel face is governed by the type of tool and the finish required on the work. General recommendations for truing with a diamond are: rough grinding, 10" to 20" per minute; finish grinding, 4" to 7" per minute. The recommended rate of travel for truing with a metallic dresser is: rough grinding, 40" to 60" per minute; finish grinding 10" to 20" per minute. While truing with a diamond or metallic rotary dresser, a good volume of coolant should be flowing on the wheel to reduce heat and wash away the grit removed by the truing operation. The depth of cut should not be more than 0.001 inch per pass across the face of the wheel.

Regulating Wheel

The general-purpose regulating wheels, 2A80-R-BR, have proved satisfactory for most work. There are harder grades and finer grain sizes available for special applica-

tions when needed. The harder grades are used when the regulating wheels must be very thin and the general-purpose grade deflects under the pressure of the grind. Harder grades also offer some advantage when work must be ground to very close tolerances, and when there is excessive regulating wheel wear due to the design of the work when grinding two or more diameters and one is much larger than the other. The difference in sfpm causes one of the diameters to slip or skid in contact with the wheel. The general-purpose grade gives a better drive or braking action and will resist spinning more than the finer, harder wheels on average work. The average starting speed of the regulating wheel is from 22 to 39 rpm, and for general work the angle of inclination of 3° is recommended as a starting point. However, both the angle and wheel speed can be changed to suit specific conditions. The steeper the angle, the faster the traverse rate. The flatter the angle, the slower the traverse rate.The wheel speed also affects the traverse rate. The faster the wheel speed, the faster the traverse rate, and conversely, the slower the wheel speed, the slower the traverse rate. For work that is warped from hardening or machining, the best straightening effect can be obtained by using a high traverse rate or by increasing the angle of the regulating wheel. For work that is straight, but out-of-round, a faster rounding-up action can be obtained by using a higher regulating wheel speed and a flatter angle. This does not necessarily mean less production from the machine, because increasing the wheel rpm and reducing the angle of the regulating wheel could give approximately the same traverse rate.

Truing The Regulating Wheel: Thrufeed Work

The regulating wheel must be trued to a special shape so that the work, while passing between the wheels, makes a straight-line contact with the wheel face. Four factors must be considered to set the truing unit to form this shape:

1. Angle of inclination of the regulating wheel.
2. Location of the center of the work with respect to the centerline of the grinding and regulating wheels.
3. The angle to which the regulating wheel truing slide is swiveled.
4. The amount the diamond holder is set over.

The first factor is fixed by the work. A general recommendation for most thrufeed setups is a positive inclination of 3° as a starting point.

The second factor is fixed by the diameter of the work. Generally, work is ground with its center above the centerline of the grinding and regulating wheels. For small work up to 1" diameter, adjust the blade to position the work one half of its diameter above the centerline of the wheels. For larger work, the above center adjustment seldom exceeds ½ inch.

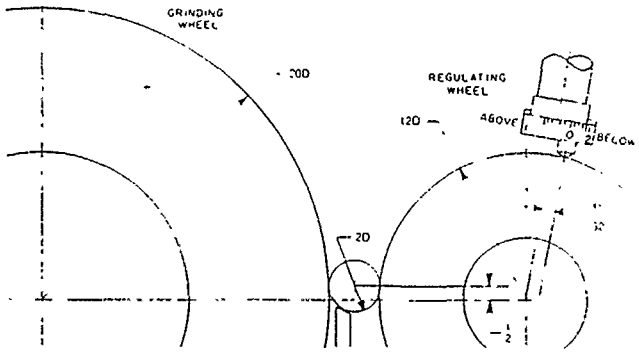
The third and fourth factors are based on the ratio of the diameter of the regulating wheel and the diameter of the workpiece. Determine the ratio by dividing the diameter of the regulating wheel by the diameter of the workpiece. After establishing this ratio, refer to the following chart to determine the correct truing angle for the truing slide and the correct diamond holder setting for dressing the special shape required on the regulating wheel.

Table Of Truing Angles And Heights Above Center For Regulating Wheel Truing

	Truing Angle Setting										
WORK FEED ANGLE*	7°	6° 10'	6° 10'	6° 20'	6° 25'	6°30'	6°35'	6° 45'	6° 50'	6° 55'	6° 55'
	6°	5°15'	5°15'	5°25'	5°30'	5°35'	5°40'	5°45'	5°55'	5°55'	5°55'
	5°	4°20'	4°25'	4° 30'	4°35'	4°40'	4°40'	4°50	4°55'	5°	5
	4°	3°30'	3°30'	3° 35'	3°40'	3°45'	3°45'	3°50'	3° 55'	4	4
	3	2° 35'	2° 40'	2°40'	2°45'	2°50'	2°50'	2° 55'	2° 55'	3	3
	2	1° 45'	1°45'	1°50'	1°50'	1°50'	1°55'	1°55'	2	2°	2
	1°	50'	50'	55'	55'	55'	55'	55'	1	1	1°
RATIO D/d		3	3.5	4	5	6	7	12	18	24	48
WORK HEIGHT ABOVE CENTER†	1/8"	7/64"	7/64"	7/64"	7/64"	7/64"	1/8"	1/8"	1/8"	1/8"	1/8"
	1/4"	7/32"	7/32"	7/32"	15/64"	15/64"	15/64"	15/64"	1/4"	1/4"	1/4"
	3/8"	21/64	21/64"	11/32"	11/32"	11/32"	23/64"	23/64"	23/64"	3/8"	3/8"
	1/2"	7/16"	7/16"	29/64"	29/64"	15/32"	15/32"	31/64"	31/64"	1/2"	1/2"
	5/8"	35/64"	35/64"	9/16"	37/64"	37/64"	19/32"	19/32"	29/64"	5/8"	5/8
	3/4"	21/32	21/32"	43/64"	11/16"	45/64"	45/64"	23/32"	47/64"	47/64"	47/64
	7/8"	3/4"	29/64"	25/32"	51/64"	13/16"	55/64"	27/32"	55/64	55/64"	55/64
	1"	55/64"	7/8"	29/32	59/64"	15/16"	15/16"	61/64"	63/64"	63/64"	63/64

To use the chart, consider a setup with a 3° angle of inclination, 2 work diameter, ½" height above center, 12" diameter regulating wheel.

To determine the ratio, divide the diameter of regulating wheel by the diameter of the work (12 divided by 2 = 6 ratio). Note chart — ratio 6 — read up on the chart to the line extending from 3° — note angle to swivel truing slide is 2°50'. To determine the diamond holder setting, read down on the chart from ratio 6 to the line extending from ½" work height above center; note diamond holder 15/32 above center. See Sketch No. 15.



Sketch No 15

Truing The Regulating Wheel: Infeed Work

Angle of inclination: Since the work does not traverse between the wheels, there is very little angle required. An angle between 0° and ¼° is recommended to hold the work against the end-stop during grinding.

The position of the center of the work in relation to the centerline of the wheels is the same for infeed as thrufeed. Raise the center of the work above the centerline of the wheel an amount equal to ½ the work diameter for work 1" diameter and smaller, to ½" maximum for work larger than 1".

The regulating wheel truing slide is swiveled the same amount as the angle of inclination except when truing a special shape form the profile truing cam. When truing from the cam, the slide should be set at zero.

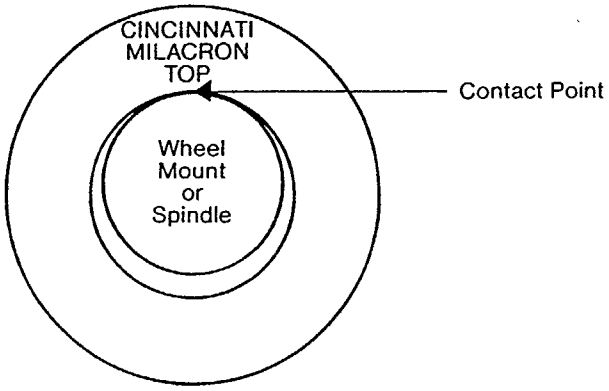
The diamond holder should be set over for infeed work the same as for thrufeed work; however, if dressing a special shape from the profile cam, the diamond holder should be set at zero.

The workpiece may be set at any height above center to obtain required roundness. With a small angle of inclination, the line of contact of the workpiece will be full at any height above center. However, if the angle of inclination is increased beyond 1/4°, the full line of contact will not result and further corrections will have to be made to set full line contact between the regulating wheel and workpiece.

How To Use "Top" Mark When Mounting CINCINNATI MILACRON Grinding Wheels

On-Machine Mounting

The TOP mark indicates the point of contact between wheel and spindle when the wheel's OD was trued at Cincinnati. Wheel user should mount wheel in the same way (i.e. align TOP with point of contact) to minimize OD runout and truing. Typical mountings are shown schematically below.



Mounting Wheels On TWIN GRIP Centerless Grinders

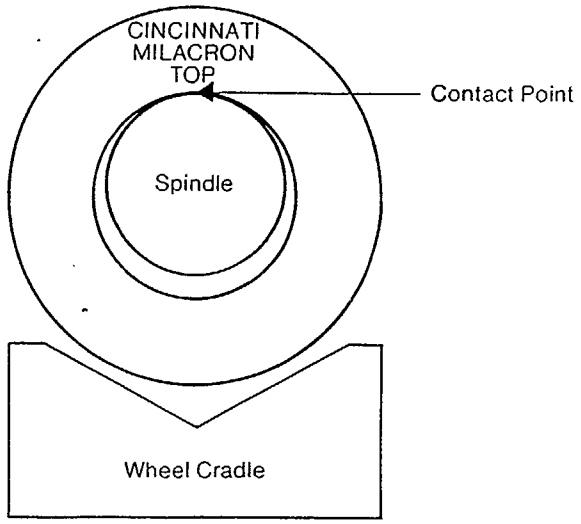
The Operators Hand Book has a comprehensive section on proper wheel mounting methods. Here are a few tips to make the job easier.

1. With wheels resting in cradle, install rear blotter, insert the spindle cartridge.
2. Install front blotter, flange, and bolts and snug up finger tight.

Off-Machine Mounting Of TWIN GRIP Wheels

Set wheel on cradle with TOP at 12 o'clock position. Place a blotter on fixed flange and insert spindle into wheel bore. Place a blotter on loose flange and mate flange with spindle; secure it with one screw, finger tight. Lift spindle-wheel assembly off cradle as shown.

Insert remaining flange screws and tighten them, in approved manner, while wheel is suspended as shown. *See photo opposite page.*



3. Raise assembly from the cradle, and tighten bolts with a torque wrench. *NOTE*: Wheel should be mounted with *top up.*
4. For wide wheel twingrips (18-20"), torque bolts to 45 foot pounds; for smaller twingrips (10-12") 35 foot pounds is sufficient.
5. Retorque the clamping flange bolts after the first 8 hours of operation.

MIL 000114

Table of Thrufeed Work Traverse Rates
Inches Per Minute

The rate at which the work feeds past the grinding wheel on thrufeed jobs depends upon the diameter, speed of rotation, and angle of inclination of the regulating wheel. the following table gives the approximate theoretical work feed rates in inches per minute for all combinations of these three variables.

Reg. Wheel Angle	Reg. Wheel Diam.	Regulating Wheel Speeds, R.P.M.										
		10 r.p.m.	15 r.p.m.	20 r.p.m.	25 r.p.m.	30 r.p.m.	40 r.p.m.	50 r.p.m.	70 r.p.m.	90 r.p.m.	125 r.p.m.	150 r.p.m.
1°	8.0"	4.4	6.6	8.8	11.0	13.2	17.5	21.9	30.7	39.5	54.8	70.2
	8.5	4.7	7.0	9.3	11.6	14.0	18.6	23.3	32.6	41.9	58.2	74.6
	9.0	4.9	7.4	9.9	12.3	14.8	19.7	24.7	34.5	44.4	61.7	78.9
	9.5	5.2	7.8	10.4	13.0	15.6	20.8	26.0	36.5	46.9	65.1	83.3
	10.0	5.5	8.2	11.0	13.7	16.4	21.9	27.4	38.4	49.3	68.5	87.7
	10.5	5.8	8.6	11.5	14.4	17.3	23.0	28.8	40.3	51.8	72.0	92.1
	11.0	6.0	9.0	12.1	15.1	18.1	24.1	30.2	42.2	54.3	75.4	96.5
	11.5	6.3	9.5	12.6	15.8	18.9	25.2	31.5	44.1	56.7	78.8	100.9
	12.0	6.6	9.9	13.2	16.4	19.7	26.3	32.9	46.0	59.2	82.2	105.3
	12.5	6.9	10.3	13.7	17.1	20.5	27.4	34.2	47.9	61.6	85.6	109.7
	13.0	7.1	10.7	14.3	17.8	21.3	28.5	35.6	49.8	64.1	89.0	114.1
	13.5	7.4	11.1	14.8	18.5	22.1	29.6	36.9	51.7	66.5	92.4	118.5
	14.0	7.6	11.5	15.4	19.2	22.9	30.7	38.3	53.6	69.0	95.8	122.9
2°	8.0"	8.8	13.2	17.5	21.9	26.3	35.1	43.9	61.4	78.9	109.6	140.3
	8.5	9.3	14.0	18.6	23.3	28.0	37.3	46.6	65.2	83.9	116.5	149.1
	9.0	9.9	14.8	19.7	24.7	29.6	39.5	49.3	69.1	88.8	123.3	157.9
	9.5	10.4	15.6	20.8	26.0	31.2	41.7	52.1	72.9	93.7	130.2	166.7
	10.0	11.0	16.4	21.9	27.4	32.9	43.9	54.8	76.7	98.7	137.1	175.4
	10.5	11.5	17.3	23.0	28.8	34.5	46.0	57.6	80.6	103.6	143.9	184.2
	11.0	12.1	18.1	24.1	30.2	36.2	48.2	60.3	84.4	108.5	150.8	193.0
	11.5	12.6	18.9	25.2	31.5	37.8	50.4	63.0	88.3	113.5	157.6	201.7
	12.0	13.2	19.7	26.3	32.9	39.5	52.6	65.8	92.1	118.4	164.5	210.5
	12.5	13.7	20.5	27.4	33.2	41.1	54.8	68.5	96.0	123.4	171.3	219.2
	13.0	14.3	21.3	28.5	33.6	42.8	57.0	71;3	99.8	128.3	174.2	228.5
	13.5	14.8	22.1	29.6	33.9	44.4	59.2	74.0	103.7	133.3	177.0	236.7
	14.0	15.4	22.9	30.7	34.3	46.1	61.4	76.8	107.5	138.2	183.9	245.5
3°	8.0"	13.2	19.7	26.3	32.9	39.5	52.6	65.8	92.1	118.4	164.4	210.5
	8.5	14.0	21.0	28.0	34.9	41.9	55.9	69.9	97.8	125.8	174.7	223.6
	9.0	14.8	22.2	29.6	37.0	44.4	59.2	74.0	103.6	133.2	185.0	236.8
	9.5	15.6	23.4	31.2	39.1	46.9	62.5	78.1	109.3	140.6	195.3	249.9
	10.0	16.4	24.7	32.9	41.1	49.3	65.8	82.2	115.1	148.0	205.5	263.1
	10.5	17.3	25.9	34.5	43.2	51.8	69.1	86.3	120.9	155.4	215.8	276.2
	11.0	18.1	27.1	36.2	45.2	54.3	72.3	90.4	126.6	162.8	226.1	289.4
	11.5	18.9	28.4	37.8	47.3	56.7	75.6	94.5	132.4	170.2	236.4	302.6
	12.0	19.7	29.6	39.5	49.3	59.2	78.9	98.7	138.1	177.6	246.6	315.7
	12.5	20.5	30.9	41.1	51.4	61.6	82.2	102.8	143.9	185.0	256.9	328.8
	13.0	21.3	32.1	42.8	53.4	64.1	85.5	106.9	149.6	192.4	267.2	341.9
	13.5	22.1	33.4	44.4	55.5	66.5	88.8	111.0	155.4	199.8	277.5	355.0
	14.0	22.9	34.6	46.1	57.5	69.0	92.1	115.1	161.1	207.2	287.8	368.1

Table of Thrufeed Work Traverse Rates (cont.)

Reg. Wheel Angle	Reg. Wheel Diam.	Regulating Wheel Speeds, R.P.M.										
		10 r.p.m.	15 r.p.m.	20 r.p.m.	25 r.p.m.	30 r.p.m.	40 r.p.m.	50 r.p.m.	70 r.p.m.	90 r.p.m.	125 r.p.m.	150 r.p.m.
4°	8.0"	17.5	26.3	35.1	43.8	52.6	70.1	87.7	122.7	157.8	219.2	280.5
	8.5	18.6	27.9	37.3	46.6	55.9	74.5	93.1	130.4	167.7	232.9	298.1
	9.0	19.7	29.6	39.4	49.3	59.2	78.9	98.6	138.1	177.5	246.6	315.6
	9.5	20.8	31.2	41.6	52.1	62.5	83.3	104.1	145.7	187.4	260.3	333.1
	10.0	21.9	32.9	43.8	54.8	65.7	87.7	109.6	153.4	197.2	273.9	350.7
	10.5	23.0	34.5	46.0	57.5	69.0	92.0	115.1	161.1	207.1	287.6	368.2
	11.0	24.1	36.2	48.2	60.3	72.3	96.4	120.5	168.8	217.0	301.3	385.7
	11.5	25.2	37.8	50.4	63.0	75.6	100.8	126.0	176.4	226.8	315.0	403.3
	12.0	26.3	39.4	52.6	67.7	78.9	105.2	131.5	184.1	236.7	328.7	420.8
	12.5	27.4	41.0	54.8	68.5	82.2	109.6	136.9	191.7	246.5	342.4	438.4
	13.0	28.5	42.5	57.0	71.3	85.5	114.0	142.4	199.4	256.4	356.1	456.0
	13 5	29.6	44.2	59.2	74.1	88.8	118.4	147.8	207.0	266.2	369.8	473.6
	14.0	30.7	45.8	61.4	76.9	92.1	122.8	153.3	214.7	276.1	383.5	491.2
5°	8.0"	21.9	32.9	43.8	54.8	65.7	87.6	109.5	153.3	197.2	273.8	350.5
	8.5	23.3	34.9	46.5	58.2	69.8	93.1	116.4	162.9	209.5	290.9	372.4
	9.0	24.6	37.0	49.3	61.6	73.9	98.6	123.2	172.5	221.8	308.0	394.3
	9.5	26.0	39.0	52.0	65.0	78.0	104.1	130.1	182.1	234.1	325.2	416.2
	10.0	27.4	41.1	54.8	68.5	82.1	109.5	136.9	191.7	246.4	342.3	438.1
	10.5	28.8	43.1	57.5	71.9	86.3	115.0	143.8	201.3	258.8	359.4	460.0
	11.0	30.1	45.2	60.2	75.3	90.4	120.5	150.6	210.8	271.1	376.5	481.9
	11.5	31.5	47.2	63.0	78.7	94.5	126.0	157.4	220.4	283.4	393.6	503.8
	12.0	32.9	49.3	65.7	82.1	98.6	131.4	164.3	230.0	295.7	410.7	525.7
	12.5	34.3	51.3	68.5	85.5	102.7	136.9	171.2	239.6	308.0	427.8	547.6
	13.0	35.7	53.4	71.2	88.9	106.8	142.4	178.1	249.2	320.3	444.9	560.5
	13.5	37.1	55.4	74.0	92.3	110.9	147.9	184.0	258.8	332.6	462.0	591.4
	14.0	38.5	57.5	76.7	95.7	115.0	153.4	191.9	268.4	344.9	471.9	613.3
6°	8.0"	26.3	39.4	52.5	65.7	78.8	105.1	131.4	183.9	236.4	328.4	420.3
	8.5	27.9	41.9	55.8	69.8	83.7	111.7	139.6	195.4	251.2	348.9	446.6
	9.0	29.6	44.3	59.1	73.9	88.7	118.2	147.8	206.9	266.0	369.4	472.9
	9.5	31.2	46.8	62.4	78.0	93.6	124.8	156.0	218.4	280.8	390.0	499.2
	10.0	32.8	49.3	65.7	82.1	98.5	131.4	164.2	229.9	295.6	410.5	525.4
	10.5	34.5	51.7	69.0	86.2	103.4	137.9	172.4	241.4	310.3	431.0	551.7
	11.0	36.1	54.2	72.2	90.3	108.4	144.5	180.6	252.9	325.1	451.5	578.0
	11 5	37.8	56.6	75.5	94.4	113.3	151.1	188.8	264.4	339.9	472.1	604.2
	12.0	39.4	59.1	78.8	98.5	118.2	157.6	197.0	275.8	354.7	492.6	630.5
	12.5	41.0	61.6	82.1	102.6	123.1	164.3	205.2	287.4	369.5	513.1	656.8
	13.0	42.6	64.1	85.4	106.7	128.0	170.9	213.4	298.9	384.3	533.6	683.1
	13.5	44.2	66.6	88.7	110.8	132.9	177.5	221.6	310.4	399.1	554.1	709.4
	14.0	45.8	69.1	92.0	114.9	137.8	184.1	229.8	321.9	413.9	574.6	735.7
7°	8 0"	30 6	45.9	61 3	76.6	91.9	122.5	153.1	214.4	275.7	382.9	490.1
	8 5	32.5	48.8	65.1	81.4	97.6	130.2	162.7	227.8	292.9	406.8	520.7
	9 0	34.5	51.7	68 9	86.1	103.4	137.8	172.3	241.2	310.1	430.7	551.3
	9.5	36.4	54.6	72.7	90.9	109.1	145.5	181 9	254.6	327.4	454.7	582.0
	10.0	38.3	57 4	76.6	95.7	114.9	153.1	191.4	268.0	344.6	478.6	612.6
	10.5	40.2	60 3	80.4	100.5	120.6	160.8	201.0	281.4	361.8	502.5	643.2
	11 0	42.1	63.2	84.2	105.3	126.3	168.5	210 6	294.8	379.0	526.4	673.8
	11 5	44.0	66.0	88.1	110.1	132.1	176.1	220.1	308.2	396.3	550.4	704.5
	12 0	45 9	68.9	91 9	114.9	137 8	183 8	229.7	321.6	413.5	574.3	735.1
	12.5	47 8	71 8	95.7	119.7	143.5	191.5	239.3	335.0	430.7	598.2	765.7
	13 0	49.7	74.7	99.5	124.5	149.2	199.2	248 9	348.4	447.9	622.1	796.3

Typical Centerless Applications

Selection of traverse rates for thrufeed work depends upon so many factors that it is not practical to compile exact tables for all the conditions which may be encountered. Perhaps the reason will be more apparent if we tabulate some of these factors: work material (including physical characteristics), stock removal, accuracy standards, blade material, type of grinding wheel, finish desired, diameter of part, weight of part, coolant available, and physical condition of machine. Practically every job must be considered on its own merits. A good practice is to keep complete job records and use it as a guide in setting up duplicate or similar jobs. A few examples are given here to provide a starting point in selecting the correct traverse rate. All of them have been checked by time studies and represent actual job shop practice. Under high volume production conditions, the use of larger machines with higher horsepowers and wider wheels could be easily justified to reduce the number of operations.

PISTON PIN

Size — 7/8" diameter x 3 1/16" long.
Material — Hardened steel.
Stock Removal — .015" in four roughing and two finishing cuts.
Finish — High grade commercial.
Wheel — 97A-601-J6-VRW.
Traverse Rate — 12 feet per minute per cut.
Machine — 220-8 Centerless.

CHAIN ROLLER PIN

Size — 5/32" diameter x 7/16" long.
Material — Hardened steel.
Stock Removal — .005" to .008", one cut.
Finish — High grade commercial.
Wheel — 97A-601-M4-VRW.
Traverse Rate — 7 feet per minute per cut.
Machine — 220-8 Centerless.

STEEL ROD

Size — 5/8" diameter x 12" long.
Material — Soft steel.
Stock Removal — .010" to .015", three cuts.
Finish — Commercial.
Wheel — 97A-601-J6-VRW.
Traverse Rate — 7 feet per minute per cut.
Machine — 220-8 Centerless.

PISTON

Size — 3 3/16" diameter x 4" long.
Material — Cast iron.
Stock Removal — .005" three cuts.
Finish — Good commercial.
Wheel — 6C-46-K6-VSC.
Traverse Rate — 5 feet per minute per cut.
Machine — 325-12 Centerless.

Add "E" to bond symbol of wheel speed is greater than 6500 SFPM vitrified and 9500 resin.

FIN-TECH Finishing Technologies

This fine grit product is available in grit sizes ranging from 220-1200. These wheels will produce finishes in the 2 - 4 micro inch Ra range.

FIN-TECH Grinding Wheels for cylindrical and centerless grinding in thrufeed and plunge cut operations offer many technical and economical advantages.

These FIN-TECH products are well suited and designed for the grinding of:

- Struts
- Rods, Piston Pins
- Needles, Rollers
- Roll Grinding
- Razor Blades
- Hypodermic Needles

Thrufeed Grinding

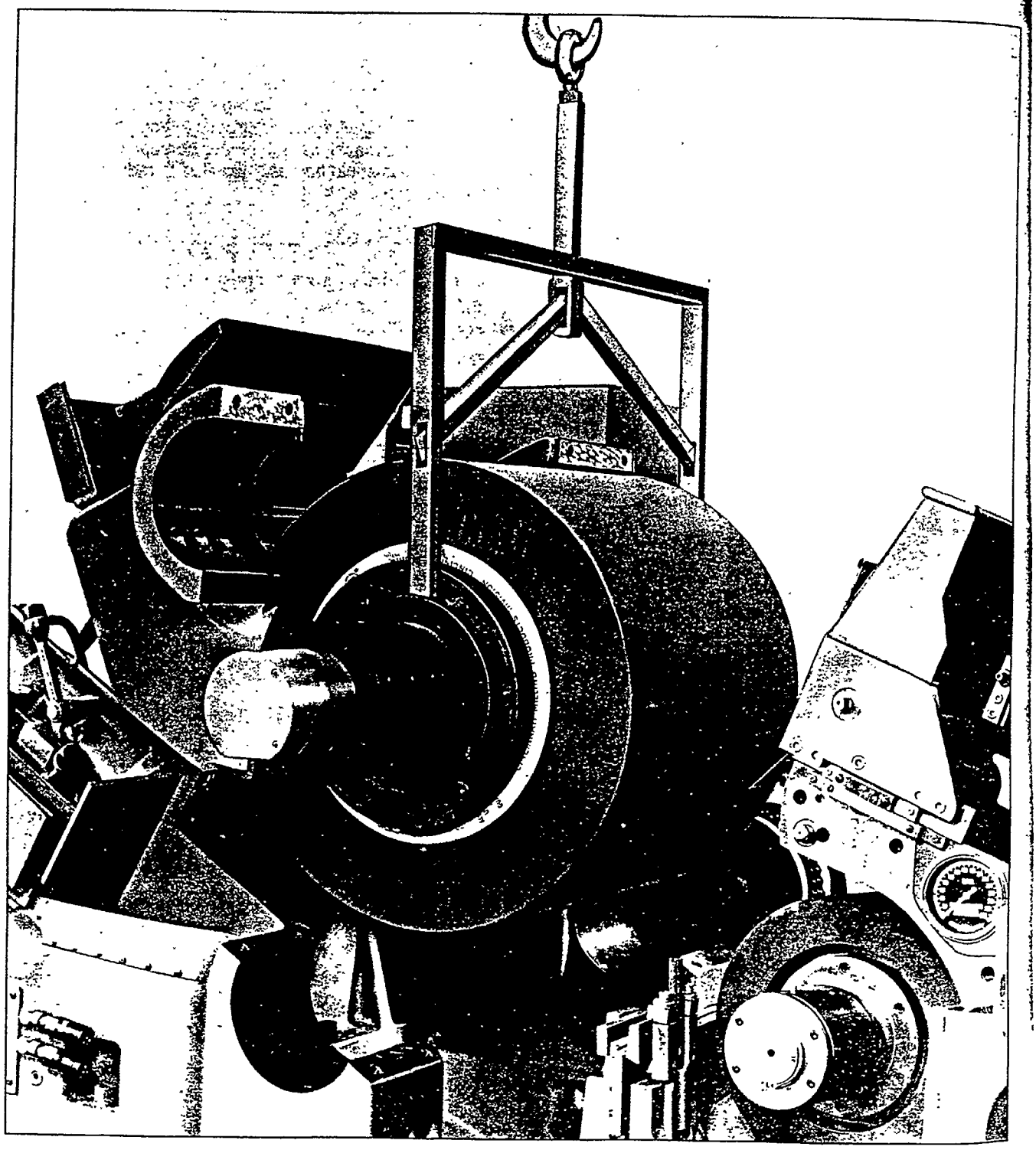
- Increase of thrufeed speed in conjunction with maximum rate of metal removal.
- Reduction of dressing time.
- Superior surface quality.
- Very fine surface finishes produced 2-4 micro inch Ra.
- Very consistant surface finishes from .3-.6 micrometer Rz.

Plunge Cut Grinding

- Excellent profile stability.
- Good cutting characteristics which increase productivity.

FIN-TECH Availability

	Resin Bond *Bond Designator: BFG*	Vitrified Bond *Bond Designator: VGF*
Diameter:	5.9 - 43 3 in. 150 - 1100mm	Max. 24 in. Max. 610mm
Thickness:	.98 - 11.8 in. 25 - 300mm	Max. 4.7 in. Max. 120mm
Grit Sizes:	220 - 1200	220 - 600
Structure	7 - 18	7 - 12



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A. Burn Marks On Workpiece

1. Insufficient coolant
2. Dull or flat diamond
3. Wheel too hard
4. Cutting on trailing edge of the wheel
5. Grinding wheel dressed with diamond traverse too slow.
6. Too heavy stock removal

B. Chatter

1. Work too high above center
2. Wheel out of balance
3. Blade angle too steep (30° standard)
4. Blade too thin or warped
5. Machine leveling screws not adjusted for even torque when machine is finally leveled
6. Glazed wheel caused by dull diamond, wheel too hard, grit size too fine or dressing rate too slow
7. Outside "Floor Harmonics"
8. Motors out of balance
9. Grinding wheel mount fits loosely on spindle
10. Stock removal too heavy
11. Blade not properly clamped
12. Blade being used too long for width of wheel

C. Dull Diamond — Grinding Wheel Truing Attachment

1. Diamond nib not turned periodically
2. Excessive infeed of diamond (should not take more than 0.001" depth of cut under normal conditions)

D. Erratic Sizing

1. Gibs not properly adjusted on upper and lower slides
2. Wear in infeed screw and nut
3. Infeed lever not held tight (for thrufeed work)
4. Soft wheel
5. Insufficient lubrication on lower slides causing slides to hang or jump (infeed)
6. Improper tension on backlash spring
7. Loose work support blade
8. Parts overheating during cut, due to improper wheel or insufficient coolant
9. Regulating wheel camming
10. Work improperly rough ground

E. Feed Lines

1. Grinding wheel not relieved on exit side
2. Work guides not properly set
3. On long bar fixtures — excessive pressure on workpiece by roller hold-down

F. Finish

1. Improper wheel grade
2. Dirty or insufficient coolant
3. Setup not correct
4. Diamond dressing traverse rate too fast
5. Erratic movement of truing attachments
6. Pick-up on blade
7. Blade not tight in work rest
8. Blade angle too steep
9. Unbalanced wheel
10. Loose, cracked or dull diamond
11. Oil on face of wheel
12. Regulating wheel not tight on its mount
13. Work too high above center
14. Regulating wheel SFM excessive

G. Fish Tails (Scratches)

1. Dirty coolant
2. Loose grit in wheel

H. Grinding Wheel

1. Too hard
   a. May cause burn marks
   b. Can cause squeal because it is not free cutting
   c. Glazing may occur on wheel face
   d. Soft materials may "load" wheel
   e. Often produce chatter on workpiece
   f. Sizing trouble, due to no spark out
   g. May cause heat checks or cracks
2. Too soft
   a. Sizing trouble, because wheel breaks down rapidly.
   b. Chatter may develop
   c. Rough finish

I. Height Above Center of Workpiece

1. If too high, chatter can develop
2. Optimum rounding action will not occur if center height is too low
3. Three-point out-of-roundness is a good sign of low center

J. Intermittent Cut

1. Grinding wheel not correctly trued
2. Regulating wheel "camming"
3. Warped workpiece

K. Jumpy Truing Device

1. Air in hydraulic lines
2. Slides not lubricated properly
3. Gib adjusted improperly

L. Loading Of Wheels

1. See grinding wheels (H.)
2. Wheel too fine. Larger grain size allows more chip clearance.
3. Ineffective grinding fluid — due to the lack of lubricity of grinding fluid, chips adhere to grit of wheel. Change to coolant with greater lubricity or increase amount of concentration in mix.

M. Low Ends On Work — Chamfered

1. Work guides deflected toward regulating wheel
2. Face of regulating wheel not straight at work contact point (truing device worn or not on correct angle)

N. Low Center — High Ends

1. Work guides deflected toward grinding wheel
2. Face of regulating wheel not straight at work contact point (truing device work or not on correct angle)

O. Nicks In Workpiece

1. Do not drop parts into tote pans. Provide bumpers to cushion workpiece.

P. Out Of Round Work

1. Out of balance workpiece
2. Work not high enough above center
3. Workpiece bowed
4. Regulating wheel not dressed round
5. Regulating wheel loose on mount
6. Blade angle not steep enough
7. Not enough stock to round up
8. Regulating wheel speed too slow
9. Interrupted cut due to keyways, holes, flats, etc.
10. On infeed only end stop or ejector may be worn on locating surface
11. Grinding wheel not properly graded for job
12. Flat diamond

Q. Pick-Up On Blade

1. Grinding fluid not lubricating work-to-blade contact point. Use grinding fluid with greater lubricity or increase concentration.
2. Blade too hard for material being ground (use cast iron or bronze blade)

R. Regulating Wheel "Camming"

1. Collet screws loose
2. Bearings worn
3. Regulating wheel spindle eccentric or out of round

S. "Spiral Chatter"

1. Improper wheel grade
2. Chipped edge of wheel
3. Loose machine elements

T. Straightness

1. Work not straightened sufficiently before grinding
2. Insufficient grinding stock left on workpiece
3. Too much stock removal on first pass
4. Wheel not cutting freely (part heats up, relieving internal stresses to cause part to bow)
5. Insufficient coolant (same thing happens)

U. Taper

1. Work guides not set properly
2. Dirt under workrest or blade
3. Loose gibs
4. Failure to keep parts butted end to end on thrufeed
5. Too much feeding pressure (race grinding fixture)
6. Non-uniform spark out time from one piece to the next (infeed setup)
7. Wheel not cutting freely (part expands due to surface temperature immediately behind leading end. This results in tapered part with leading end high.)

V. Vibration

1. Check outside sources
2. Leveling screws not snug against floor
3. Motors not balanced or drive belts too loose
4. Faulty hydraulic pump causing erratic pressure vibrations to be transmitted to machine

W. Warped Work (Usually Long Bar Or Tubing)

1. Insufficient flow of coolant
2. Wheel not cutting efficiently. Either dressed too fine or too small grit size.
3. Workpiece not straightened before grinding

X. See Back Cover For Helpful Hints to Problem Solving

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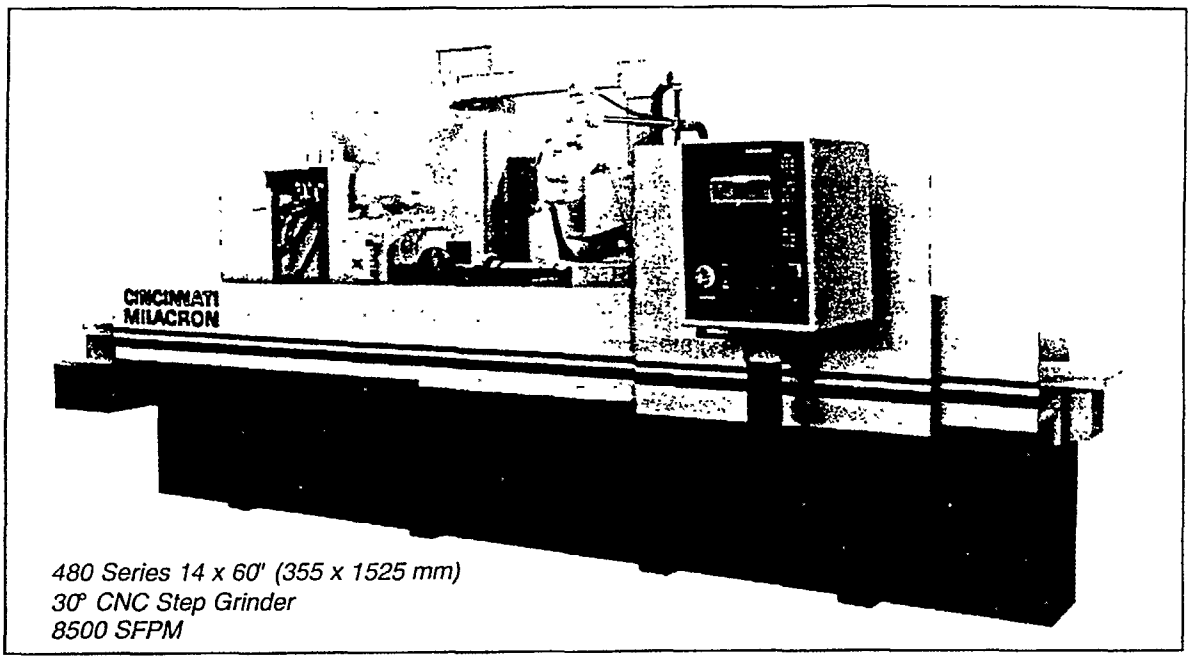
5 Centertype Grinding Wheels



480 Series 14 x 60" (355 x 1525 mm)
30° CNC Step Grinder
8500 SFPM

Step up your production rates with our 480 Series Step Grinder, a complete CNC centertype grinding package, especially designed to provide maximum performance with flexibility for the precision grinding of your multi-diameter, cylindrical parts. Automatically grind multiple OD's, shoulders, tapers and radii all in one continuous operation. Our ACRAMATIC 760G Grinding Control makes it easy.

Choose either the 0 degree "straight" or the 30 degree "angular" wheelhead version to suit your part mix. A variety of machine configurations offers a range of capacities with 14 or 24" (355 or 610 mm) of swing, up to 12" (305 mm) of wheel width, and 20, 40, 60, 80 or 100" (510, 1015, 1525, 2030 or 2540 mm) between centers.

Speed Programming and Setup Times, Spend More Time Grinding

The ACRAMATIC 760G CNC gets you into production fast. Programs are entered through a single page display. Color touch screen, pop-up windows, and the use of normal grinding terminology speed entry. Simple parts can be ground manually with an electronic handwheel, giving you the precision of servo-controlled digital feed and the benefit of automatic dressing without programming. Setup and alignment data can be re-used from job to job.

Advanced CNC technology plus these innovative, standard features make setups fast and simple.

- **Dead Spindle Headstock** — This variable speed unit has a broad range of part rotational speeds, programmable in rpm, surface speed or constant surface speed. A live spindle option allows work to be mounted in chucks, or ground between centers.
- **Eccentric Quill Footstock** — Fast, fingertip taper corrections are possible — without swiveling the table — by using the eccentric quill adjustment knob located on the top of the footstock.
- **Automatic Flagging** — This programmable, automatic flagging gage provides accurate closed-loop lateral (Z-axis) positioning. It allows for flip over, groove or mandrel-mounted part flagging, and is bi-directional with setup change.
- **CNC Table-Type Dresser** — This unit, which can be mounted on either the headstock or footstock, is used in combination with the ACRAMATIC 760G CNC's table dressing software. True CNC flexibility to dress both basic and complex wheel forms is possible, a necessity in multiple contour OD grinding.
- **In-Process Gaging Alternatives** — Several electronic gaging options are available for grinding continuous as well as interrupted surfaces to extremely close tolerances.

Material	Specification
ALNICO	29A601-K6-VFM
ALUMINUM	C54-K5-V8
ARMATURES, Laminated	6C60-K6-VSC
AXLES	
Automobile	97A601-J4-VFM
Railway	97A541-K6-VFM
BOLTS, Case-Hardened Steel	97A601-K6-VFM
BRONZE, Hard	C54-K5-V8
CAM SHAFT BEARINGS	29A701-J6-VFM
CAR WHEELS, Regrinding	97A541-L4-VFM
Chilled Iron	
High Speed	6C60-J6-VSC
Low Speed	6C46-L6-VSC
Steel	
High Speed	29A601-J6-VFM
Low Speed	97A461-L6-VFM
CAST IRON	6C46-K6-VSC
CEMENTED CARBIDE	
Roughing	CMD220-N100-B
Finishing	CMD220-P100-B
CHROMIUM PLATING	
Commercial Finish	12A60-K6-VFM
COPPER	7C801-K6-VSC
CRANKSHAFTS	
Roughing	97A541-N4-VFM
Finishing	29A701-L4-VFM
Rough and Finish	97A701-M4-VFM
Regrinding	29A801-K6-VFM
GAGES, Plug	9A80-J6-VFM
GLASS TUBING	5C100-J6-VSC
MEEHANITE	7C461-L6-VSC
MONEL METAL	7C601-J6-VSC
NITRALLOY	
Before Nitriding	FA46-H5-V9
After Nitriding	29A601-J6-VFM
PISTONS	
Aluminum Alloy	7C461-K6-VSC
Cast Iron	7C461-L6-VSC
PISTON RODS, Locomotive	29A461-N4-VFM
PORCELAIN	7C461-K6-VSC
RIFLE BARRELS	97A601-K4-VFM

Material	Specification
ROLLS	
Brass and Copper	
Roughing	97A461-N9-B90
Finishing	29A1001-J6-B90
Cast Iron	
Roughing	6C36-J6-VFM
Finishing	7C801-I6-VFM
Granite	
Roughing	6C36-M6-VSC
Finishing	7C541-K4-VSC
PAPER MILL ROLLS**	
CAST IRON	7C461-M9-B90
RUBBER	
Soft	5C36-J10- VSC
Hard	7C541-J6-VSC
STEEL MILL ROLLS**	
Large Diameter 30" through 36"	
HOT MILL ROLLS	
Chilled Iron	
Roughing	6C36-N6-B90
Finishing	7C541-M9-B90
COLD MILL ROLLS	
Steel and Chilled Iron	
Finishing	97A801-L6-B90
Hardened Steel	
Roughing	97A361-N9-B90
Finishing	29A801-K7-B90
SPLINE SHAFTS	97A601-N4-VFM
STEEL	
Hardened	29A801-K4-VFM
High Speed	29A801-K4-VFM
Soft	97A601-M4-VFM
Stainless	
Heat Treated (400 Series)	7C601-K4-VSC
Free Machining (300 Series)	29A541-L6-VFM
STELLITE	7C601-N4-VSC
VALVE STEMS, Automotive	97A1001-N4-VFME
VALVE TAPPETS	97A1001-N4-VFME
GENERAL PURPOSE	
UP TO 12"	29A601-L4-VFM
OVER 12"	29A541-J6-VFM

**SEE PRECISION RESINOID RECOMMENDATIONS.
For large diameter, thin wall, or burn sensitive parts, use VA bond.
For High Precision and Form Grinding, use VRW bond.
Always establish the operating RPM before ordering.

Starting Grade Recommendations

For Hi Production With Optimum Setup Use VRW 1 Grade Softer.
For Improved Part Quality With Normal Production And Setup Use VQC 1 Grade Softer.

MATERIAL — OPERATION	LESS THAN 1" DIAMETER	1" TO 2" DIAMETER	2" TO 4" DIAMETER	4" TO 6" DIAMETER
Alnico - Cylindrical	97A601-K4-VFM	97A601-J4-VFM	97A601-14-VFM	97A601-G6-VFM
Aluminum - (Hard)	97A601-J6-VFM	97A601-I6-VFM	12A60-H6-VFM	12A60-G6-VFM
Aluminum - (Soft)	6C46-K6-VSC	6C46-J6-VSC	6C46-I6-VSC	6C46-H6-VSC
Armature	97A601-L4-VFM	97A601-K4-VFM	97A601-J4-VFM	97A601-I4-VFM
Axles (Auto)	—	97A601-J4-VFM	97A601-I4-VFM	—
Axles (Railway)	—	—	97A601-I4-VFM	97A6011-H4-VFM
Brass & Bronze (Soft)	6C60-L6-VSC	6C46-K6-VSC	6C46-K6-VSC	6C46-J6-VSC
Brass & Bronze (Hard)	97A601-J6-VFM	97A601-I6-VFM	97A601-H6-VFM	97A601-G6-VFM
Bushings (Hardened Steel)	12A80-K4-VFM	12A80-J4-VFM	12A80-14-VFM	12A80-H4-VFM
Bushings (Cast Iron)	97A601-K4-VFM	97A701-J4-VFM	97A701-I4-VFM	97A701-H4-VFM
Camshaft (Bearings)				
(Steel Forging)	—	97A601-K4-VFM	29A601-J4-VFM	—
(Cast Iron)	97A701-L4-VFM	97A701-K4-VFM	97A701-J4-VFM	—
Camshaft (Lobes)				
Steel Forging Rough	97A541-M4-VFM	97A541-M4-VFM	97A541-L4-VFM	—
Steel Forging Finish	97A701-S7-B90	97A701-R9-B90	97A701-Q9-B90	—
Cast Iron Rough	97A701-M4-VFM	97A701-M4-VFM	97A701-L4-VFM	—
Cast Iron Finish	97A701-S7-B90	97A701-R9-B90	97A701-Q9-B90	—
Cast Iron - General Purpose	6C70-L6-VSC	6C70-K6-VSC	6C70-J6-VSC	6C60-H6-VSC
Chromium Plating	12A801-K4-VFM	12A801-J4-VFM	12A801-I6-VFM	12A801-H6-VFM
Colmonoy	6C60-L6-VSC	6C60-K6-VSC	6C60-J6-VSC	6C60-I6-VSC
Commutators (Copper)	6C60-L6-VSC	6C60-K6-VSC	6C60-J6-VSC	6C60-I6-VSC
Copper	6C46-L6-VSC	6C46-K6-VSC	6C46-J6-VSC	6C60-I6-VSC
Crankshaft (Auto)				
Pin Bearings (Steel Forging)	97A541-N4-VFM	97A541-M4-VFM	97A541-M4-VFM	—
(Nodular Iron)	97A701-M4-VFM	97A701-L4-VFM	97A701-L4-VFM	—
Regrind (Forged Steel)	—	97A601-L4-VFM	97A601-K4-VFM	—
Regrind (Nodular Iron)	—	97A601-K4-VFM	97A601-K4-VFM	—
Crankshaft (Regrind)				
Sprayed Metal	6C60-L6-VSC	6C60-L6-VSC	6C60-K6-VSC	6C60-J6-VSC
Drills	97A601-L4-VFM	97A601-K4-VFM	97A601-J4-VFM	—
Forgings (Steel)	97A461-L6-VFM	97A461-K6-VFM	97A461-J6-VFM	—
Gages (Plug)	97A601-J4-VFM	97A801-I4-VFM	29A801-G6-VFM	—
Glass (Rough)	5C80-I6-VSC	5C80-H6-VSC	5C80-G6-VSC	—
(Finish)	97A1801-M4-VFM	97A1801-L4-VFM	97A1801-K4-VFM	—
General Purpose	12A60-K4-VFM	12A60-J4-VFM	12A60-I4-VFM	12A60-H4-VFM
	97A601-J6-VFM	97A601-I6-VFM	97A601-H6-VFM	97A601-H6-VFM
Monel Metal	6C46-J6-VSC	6C36-I6-VSC	6C36-H6-VSC	—
Nitralloy - Before Nitriding	97A601-J4-VFM	97A601-I6-VFM	97A601-H6-VFM	—
After Nitriding	971801-J4-VFM	97A801-I6-VFM	97A801-H6-VFM	—
Pistons (Aluminum)	6C46-K6-VSC	6C46-J6-VSC	6C36-J6-VSC	6C36-I6-VSC
(Cast Iron)	97A461-J6-VFM	97A461-I6-VFM	12A36-I6-VFM	12A36-H6-VFM
Proferall (Iron Alloy)				
Rough	97A541-M4-VFM	97A601-M4-VFM	97A601-L4-VFM	—
Finish	97A801-R9-B90	97A801-Q9-B90	97A801-P9-B90	—
Rubber Rolls (Soft)	6C361-K10-VSC	6C361-J10-VSC	6C361-H10-VSC	—
(Hard)	6C301-J9-B90	6C301-J9-B90	6C301-J9-B90	6C301-J9-B90
Steel				
General Purpose Soft	97A601-L4-VFM	97A601-K4-VFM	97A601-J6-VFM	97A601-I6-VFM
General Purpose Hardened	12A80-K4-VFM	12A80-J4-VFM	12A80-I4-VFM	12A80-H4-VFM
Stainless Steel				
300 Series	6C60-K6-VSC	6C60-J6-VSC	6C60-I6-VSC	—
400 Series	97A601-J6-VFM	97A601-I6-VFM	97A601-H6-VFM	—

***For large diameter parts, consider 29A-VA.*

Starting Grade Recommendations (cont.)

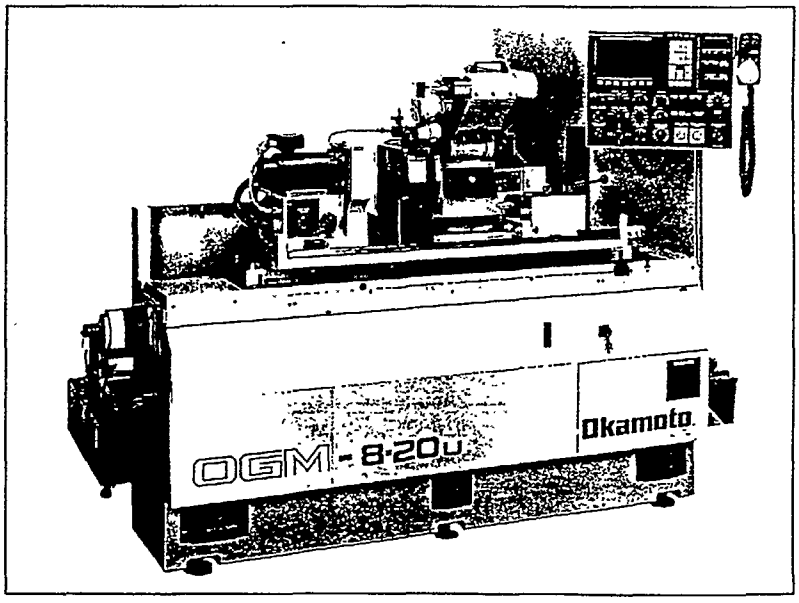
USE CLASSIFICATION	Diameter Of Work Piece LESS THAN 1"	1" TO 2"	2" TO 4"	4" TO 6"
Alloy Steel (hard)	97A801-K6-VRW	97A801-J6-VRW	29A801-I6-VRW	29A801-H6-VRW
	97A801-L6-VFM	97A801-K6-VFM	97A801-J6-VFM	97A801-I6-VFM
Alloy Steel	97A461-K6-VRW	971461-J6-VRW	97A461-I6-VRW	97A461-H6-VRW
(free machining)	97A461-L6-VFM	97A461-K6-VFM	97A461-J6-VFM	971461-I6-VFM
Carbon Steel (plain)	12A80-M4-VRW	12A80-L4-VRW	12A80-K4-VRW	12A80-J4-VRW
	12A80-N4-VFM	12A80-M4-VFM	12A80-L4-VFM	12A80-K4-VFM
Carbon Steel	2A60-L4-VRW	2A60-K4-VRW	2A60-J4-VRW	2A60-I4-VRW
(free machining)	2A60-M4-VFM	2A60-L4-VFM	2A60-K4-VFM	2A60-J4-VFM
Cast Iron	97A601-K4-VRW	97A601-J4-VRW	29A601-I4-VRW	29A601-H4-VRW
	97A601-L4-VFM	971601-K4-VFM	97A601-J4-VFM	97A601-I4-VFM
Cast Steel	2A46-M6-VRW	2A46-L6-VRW	2A46-K6-VRW	2A46-J6-VRW
	2A46-N6-VFM	2A46-M6-VFM	2A46-L6-VFM	2A46-K6-VFM
Copper Alloys	6C46-N6-VSC	6C46-M6-VSC	6C46-L6-VSC	6C46-K6-VSC
High Temperature	97A601-K6-VRW	97A601-J6-VRW	97A601-I6-VRW	97A601-H6-VRW
Alloys	97A601-L6-VFM	97A601-K6-VFM	97A601-J6-VFM	97A601-I6-VFM
Stainless Steel	97A601-L6-VRW	97A601-K6-VRW	29A601-J6-VRW	29A601-I6-VRW
(400 Series)	97A601-M6-VFM	97A601-L6-VFM	97A601-K6-VFM	97A601-J6-VFM
(300 Series)	6C60-M6-VSC	6C60-L6-VSC	6C60-K6-VSC	6C60-J6-VSC
Steel (high strength)	97A801-K6-VRW	97A801-J6-VRW	97A801-I6-VRW	97A801-H6-VRW
	97A801-L6-VFM	97A801-K6-VFM	97A801-J6-VFM	97A801-I6-VFM
Tool Steel	9A80-K6-VRW	9A80-J6-VRW	9A80-I6-VRW	9A80-H6-VRW
	9A80-L6-VFM	9A80-K6-VFM	9A80-J6-VFM	9A80-I6-VFM

**VQC will apply to most jobs where VRW is recommended.*

***For large diameter parts, consider 29A-VA.*

Centertype Wheels Commonly In Stock In Various Grades

OD x THK x ID	GRADE
30 X 2 X 12	97A601-J-VQC
30 X 2 X 12	97A601-K-VQC
30 X 2 X 12	W5A14-Q4-BF-4
Reinforced Snagging	
30 x 2 x 12	W514-R4-R4-B254-4
Reinforced Snagging	
30 x 2½ x 12	W5A14-P4-BF-8
Standard Centertype Wheels	
30 x 3 x 12	97A601-I-VQC
30 X 3 X 12	97A601-J-VQC
30 X 3 X 12	97A801-J-VQC
30 X 3 X 20	97A601-J-VQC
30 X 4 X 12	97A601-I-VQC
30 X 4 X 12	97A601-J-VQC
36 X 3 X 12	97A601-K-VQC



Okamoto OGM Series Cylindrical Grinders
Typical Wheel Grade: 29A601-J6-VFME or 3MSB601-I6-VSAE

OGM-8•10U & 8•20U Models (diameter x width x bore)
12" x (1" ~ 1-1/2") x 5"
OGM-8•10P & 8•20P Models (diameter x width x bore
14" x (1" ~ 1-1/2") x 5"

OGM-12•24U, 12•40U & 12•60U Models (diameter x width x bore)
14" x (1" ~ 1-1/2") x 5"
OGM-12•24P, 12•40P & 12•60P Models (diameter x width x bore)
16" x (1-1/2" ~ 2") x 5"

U denotes Universal *P denotes Plain*

MIL 000125

Application	Wheel Specifications
Pistons	
aluminum	6C46-I6-VSC
cast iron	6C60-J6-VSC
Piston Rods (locomotive)	97A461-L4-VFM
Plastics	
Thermoplastics	
wet	6C46-J6-VSC
	2A46-J10-VL
dry	6C36-J9-B90
Thermosetting	6C36-J9-B90
Porcelain	6C60-J6-VSC
Pulley (cast iron)	6C54-J6-VSC
Reamers	97A601-K6-VFM
Rubber	
soft	6C36-I10-VSC
hard	6C36-J10-VSC
Silver	9A100-J6-VFM
Spline Shafts	97A601-K4-VFM
Sprayed Metal	7C601-K6-VSC
Stainless Steel	
300 Series	6C60-I6-VSC
400 Series	97A601-J6-VFM
Steel (high speed)	
14" and less	9A80-I6-VFM
16" and larger	9A80-H6-VFM
Steel (soft)	
less than 1" diameter	97A601-M4-VFM
over 1" diameter	97A601-K4-VFM
Steel (hardened)	
less than 1" diameter	29A601-J4-VFM
over 1" diameter	29A601-I4-VFM
Stellite	6C54-L6-VSC
Tantalum	97A601-J6-VFM
Tap Shanks	97A701-J6-VFM
Titanium	7C601-J6-VSC
Tool Steels	See Tool Room Section
Tungsten	5C60-I6-VSC
Valve Stems (automotive)	2A60-M4-VFM
Valve Tappets	97A601-L4-VFM
Vitallium	9A60-I6-VFM

To substitute VQC or VRW for VFM go 1 grade softer.

Machine And Wheel Size

Cylindrical grinding may be considered to include all outside grinding of round work even though the finished product is not always a true cylinder. The work may be, for instance, conical in shape or it may consist of special form grinding with the face of the wheel dressed to an irregular shape. Wheels in this class include those for grinding work held between centers and in chucks.

Requirements in cylindrical grinding vary from fast stock removal (with rough finishes permissible) to ultra smooth finishes (called "mirror finishes"). In general, finishes required on the final product range from 1 RMS to 100 RMS. The average "commercial finish" will run between 16 RMS and 32 RMS. It is necessary to use coarse grit wheels with rough dressing for rapid stock removal, and fine grit wheels with fine dressing for fine finishes. Hard materials require softer grade wheels than soft work in the same diameters. Small work diameters require finer and harder wheels than large diameters. Sharp corners require finer and harder wheels with emphasis on finer grits rather than harder grades, but wide shoulders call for softer and coarser wheels, particularly if the stock is hardened.

Most wheels are Type 1, 5, or 7 and in addition may be relieved on one or both sides conforming to Types 20 to 26 inclusive. Wheels range from 10 to 42 inches in diameter and 3/4 to 6 inches thick. The larger and thicker wheels are usually recessed. They are predominantly vitrified bonded in aluminum oxide (2A-9A-97A-29A-4A-12A and silicon carbide 5C-6C and 7C).

Cylindrical wheels are used extensively throughout the automotive, aircraft, shipbuilding, engine, turbine, bearing, and metalworking machine industries as well as in general shops and toolrooms. General maximum operating speed is 6500 SFPM, although 8500 SFPM and higher speeds are used in some applications. For all speeds above 6500 SFPM for Vitrified bonds and above 9500 SFPM for Organic bonds, verify the specification recommendations with a Cincinnati Milacron Marketing Company Sales Representative. (Refer to Safety Section.)

Brown & Sharpe Manufacturing Company, Providence, RI

Machine/Model	Wheel Size	Type
No. 1 Universal (10 x 20)	6 x ½ x 2 10 x ½ x 3	1
No. 2 Universal (14 x 30)	14 x ½ x 5 14 x 1½ x 5	1
No. 3 Universal (14 x 40)	14 x 1 x 5	
No. 4 Universal (14 x 60)	14 x 1½ x 5	1
No. 5 Plain (3 x 12, 3 x 18)	14 x (⅝, ¼ 1,1½ x 2) x 5	recess diameter should be 7½"
No. 10 Plain (6 x 18, 6 x 30)	24 x (1½, 2 3,4) x 12	recess diameter should be 14½"
No. 10 Plain (old style)	12 x (1,1½, 2) x 5	1
No. 11 Plain (old style)	14 x (1,2,3) x 5	1
No. 14-J (old style)	20 x 2 x 5 20 x 3 x 5 20 x 4 x 5	1 1 Rec. 1/S8 x 1"
No. 20 (10 x 18)	30 x 2 x 12	1
No. 22 (10 x 36)	30 x (3,4) x 12	1
No. 23 (10 x 48)	24 x (4,5,6,7) x 12	(if necessary to recess, the recess diameter should be 14½")

Cincinnati Milacron, Cincinnati, OH

Machine/Model	Wheel Size	Type
12", 14", 16", 18" Universal	14 x 1 x 5	1
Model ER	14 X 1½ X 5	Rec. 1/S8 x ½
12", 14"	14 x 2 x 5	1
16" and 18"	14 x 2½ x 5	Rec. 1/S8 x ½
Universal	14 x 3 x 5	Rec. 1/S8 x 1
Model ER	14 x 4 x 5	Rec. 1/S8 x 2
4" Plain	16 x 1 x 8	1
Model OH	16 x 2 x 8 16 x 2 x 8	Rec. 1/S 10½ x ½ Rec. 2/S 10½ x ½
6" Plain Model EA and ER	20 x (1,2,3,4) x 12 24 x (1,2,3,4) x 12	1
10" Univ OL	12 x 1 x 5	
10" Light Type Model OE	20 x (1,2,3,4) x 12	(if necessary to recess, except for the 12 x 1 x 5", the recess diameter should be 14½")
10" Plain Model EA	24 x (2,3,4, 5,6) x 12	
10" Plain Model ER	24 x (2,3,4, 5,6) x 12	Recess diameter should be 14½")
14" Light Type Model OE	30 x (1½,2,3, 4,5,6) x 12	(if necessary to recess, the recess diameter should be 14½")
14" and 16"	30 x (1½,2,3,4, (5,6,7) x 20	
440 Plunge STEPTRONIC	30 x 6 x 12 36 x 6 x 12	1

Landis Tool Company, Waynesboro, PA

Machine/Model	Wheel Size	Type
Old Style Universal No. 1 & No. 11/2	10 x ½ x 5	1
Old Style Universal No. 2, No. 3 & No. 4	12 x 1 x 5 14 x 1 x 5	1
10 x 20 Type H Universal 10 x 24	10 x ½ x 3	1
Type C & CH	12 x 1 x 5	
12" Type LC & LCH Hydraulic Universal	14 x (1, 1¼ 1½) x 5	1
12", 14", 16" & 18" Type C	14 x 1¼ x 5	1
4" Type H Plain Hydraulic	16 x (1,1½,2 3) x 8	1
6" Type CH Plain Hydraulic	20x (1, 1½, 2) 3) x 8 24 x (2,2½, 3,4) x 8	(if necessary to recess, the recess diameter should be 11") 1
10", 14", 16" Type BD, C, CH, D & DC Plain Hydraulic	30 x (2,2½, 3,4) x 12	(if necessary to recess, the recess diameter should be 15½")
Old Style 10" and 20" Plain	12 x 1 x 5 14 x 1 x 5 14 x 1½,2) x 5	1 Rec. 1/S 7½ x 3/16" other side 7½ x 7/16"
Old Style 12" Plain	10 x 2 x 8 18 2½ x 8	Rec. 1/S 11 x ⅛" Rec. 0/S 11 x ⅜" Rec. 1/S 11 x ⅜" Rec. 0/S 11 x ⅝"
	18 x 3 x 8	Rec. 1/S 11 x ½" Rec. (0/S 11 x ¾"
16", 20", 24" & 28" Type B Plain Hydraulic	30 x 3 x 12	(if recessed, recess diameter is 15½")
2R Plunge Grinder	30 x (1,2,3) x 12	(if recessed, recess diameter is 15½")
4R Angle Side Plunge Grinder	36 x (1,2,3,4) x 12	(face bevel 1/side or N face) recess diameter should be 15½"

Van Norman Machine Co., Springfield, MA (Including Fitchburg Grinding Mach. Corp.)

Machine/Model	Wheel Size	Type
"Bowgage Head" (mounted on various bases or other makes of grinding machines) 6 x 32"	24 x 2 x 12 24 x 3 x 12 20 x 4 x 12 (Also found with 5, 8 or 16" hole)	1 1
Adjustable Head Types B and C	20 x 2 x 12 20 x ¾,1,1½,	1
6" Plain Type B and C	2,3) x 12 24 x (¾,1,1½,	1
10" Plain Model A 6"	2,3) x 12 18 x 2 x 5	
Old Style 8"	18 x 3 x 5	
12" Model 418 Plain	18 x 3 x 5 14 x 2 x 5	1 1

Machine And Wheel Size (cont.)

Warner and Swasey, Worchester, MA (including Norton Company)

Machine/Model	Wheel Size	Type
4" Type C Plain & Semi-Automatic	16 x (1,1¼, 1½,2) x 5	1
4" Type CTU Plain & Semi-Automatic	16 x (1,2) x 8	
	20 x 2 x 12	1
	20 x 2 x 12	Rec. 2/S 14½ x □
	20 x 3 x 12	1
6" Type C & CTU	20 x 3 x 12	Rec. 2/S 14½ x □
10" Type LC & LCTU Plain & Semi-Automatic	20 x 4 x 12	Rec. 2/S 14½ x □ 13/16
	24 x 2 x 12	1
	24 x 2 x 12	Rec. 2/S 14½ x □
	24 x 3 x 12	1
	24 x 3 x 12	Rec. 2/S 14½ x □
6" Angular Wheel Slide Semi-Automatic	24 x (2,3) x 12	1
	24 x (2,3) x 12	
	20 x (2,3,4,5) x 12	1
	20 x 2 x 12	Rec. 2/S x 14½ x □
	20 x (3,4,5,6,7) x 12	Rec. 2/S 14½ x □
10" Type C & CTU		
14" Type LC & LCTU Plain & Semi-Automatic	24 x (2, 3, 4, 5) x 12	1
	24 x 2 x 12	Rec. 2/S 14½ x □
	24 x (3,4,5) x 12	Rec. 2/S 14½ x □
	30 x (2,3) x 12	1
	30 x 2 x 12	Rec. 2/S 14½ x □
	30 x 3 x 12	Rec. 2/S 14½ x □
Old Style 6" Type A	14 x (1, 1½, 2) x 5	1
	18 x 2 x 5	1
	18 x 3 x 5	Rec 1/S 8½ x 1"
Old Style 10" to 20" Type A (with Spanner nut)	18 x 4 x 5	Rec. 1/S 8½ x 2"
	20 x 2 x 5	1
	20 x 3 x 5	Rec. 1/S 8½ x 1"
	20 x 4 x 5	Rec. 1/S 8½ x 2"
	24 x 2 x 5	1
	24 x 3 x 5	Rec. 1/S 10½ x 1"
	30 x (2,3,4) x 12	1
	30 x (3,4,5,6) x 12	Rec. 2/S 14½ x □
10" Type CD (Type D Wheel Slide)	36 x (2,3,4) x 20	1
	36 x (3,4) x 20	Rec. 2/S 22½ x □
	42 x (2,3,3½) x 20	1
	42 x (3,3½) x 20	Rec. 2/S 22½ x □
10" Type C 45° (angular wheel side)	20 x (2,3,4) x 12	with "E" face
	20 x (3,4,5,6,7) x 12	Rec. 2/S 14½ x □ with "E" face 45°
10" Angular Wheel Slide Semi-Automatic	30 x (3, 3½) x 12	
10" Type CV-4 14" Type LCV-4 Semi-Automatic Angular Wheel Slide	30 x (3,4) x 12	1
14", 16", 18" Type C Plain	24 x (2,3,4,5,6) x 12	1
	24 x 7 x 12	Rec. 2/S 14½ x 13/16
	24 x (8,9,10) x 12	
	30 x (2,3,4) x 12	
14", 16" & 18"	30 x (3,4,5,6) x 12	Rec 2/S 14½ x □

Warner and Swasey, Worchester, MA (including Norton Company) (cont'd.)

Machine/Model	Wheel Size	Type
Type C Plain	36 x (2, 3, 4) x 12	
	36 x (3, 4) x 12	Rec. 2/S 14½ x □
14" Type C-2	30 x (3, 4, 5, 6) x 12	
18" Type LC-2 Plain and Semi-Automatic		
18" & 24"	30 x (3, 4, 5, 6, 7,	1
Type C-2 Plain and Semi-Automatic	8) x 12	
	10 x (½, ¾, ⅞, 1) x 3	1
Type "L" Multipurpose	12 x ¾, x 5	
	14 x (½, ¾,) x 5	
	14 x (1, 1¼, 1½) x 5	Rec. 1/S 8 x ½"
	12 x 2 x 5	Rec. 1/S 10 x □
	12 x 2½ x 5	Rec. 1/S 10 x □
	12 x 3 x 5	Rec. 1/S 10 x □
10" Universal 12", 14", 18"	10 x 1 x 3	1
Type U-4 Universal	14 x 1½ x 5	
STEPMASTER	30 x (3, 4, 5) x 12	1
PLUNGEMASTERS	36 X (3, 4, 5) X 12	1
C-5, LC-5	24 x (2, 3, 4) x 12	
CU-5, LCU-5 C-6, LC-6	30 x (3, 4, 5) x 12	1
CU-6, LCU-6	30 x (3, 4, 5) x 12	1

MIL 000128

1. Type of Parts

A. Parts with centers such as motor shafts, output shafts, axles, crankshafts, etc.

2. Selection of Wheel Guidelines

A. Things to consider:

1. Roughing or finishing
2. Traverse or plunge
3. Stock Removal
4. Requirements of finished part

3. Grading the Wheel

A. For roughing use coarse grain and soft grade. Grade differences often depend on part size.

B. For finishing, use fine grain and medium grades and light passes. RMS will be controlled by varying the traverse rate or increasing the amount of dwell time.

C. For traverse grinding, establish a setup of work RPM with a good even infeed rate (don't crowd the grind) and a spark out period to produce the RMS required.

D. Stock removal, for heavy stock removal, use coarse grain size and medium wheel grade. When stock removal is heavy, part will usually be soft.

E. For light stock removal, use a finer grain size and a soft to medium grade J - K and slow traverse rate to obtain higher RMS. For light stock removal and good RMS, part will usually be hard.

F. Requirements of finished part for good RMS, use a finer grit size 60 - 80 and medium grade J - K. If RMS is not that critical, use a 46-60 grit J or K and change your RMS by changing the traverse rate. On plunge grinding the RMS will be controlled by the grit size and amount of spark out.

G. In centertype grinding especially, it is better to have a wheel too soft than too hard. A wheel too soft can still be used, but a wheel too hard may start to chatter just as you near final size and chop undersize in places.

Centertype Cylindrical Grinding

In centertype cylindrical grinding the work usually is held rigidly between centers and ground on the O.D. there are two general types of cylindrical grinding machines: plain and universal.

Plain centertype cylindrical machines are designed for plain cylindrical work, are good production machines, and are not readily adaptable to other types of work. The wheel slide is at 90 degrees to the table travel, and neither the wheel slide nor the head stock can be swivelled.

The universal machine wheel slide and head stock can be swivelled in relation to the table travel and can be readily adapted to do a variety of grinding jobs. The universal usually adapts to internal grinding, also.

The center holes in the work and the work centers of the machine must be round and ground or lapped to the correct angle to produce accurate work. The center holes in the work should always have a relief at the bottom to clear the point of the work center. If the point of the work center touches the bottom of the center hole, the work will revolve on the point instead of bearing on the angle, and the shaft will wobble around causing out-of-round work. The cylindrical grinding of any work between centers cannot be more accurate than the center holes or the work centers.

Steadyrests

Steadyrests are necessary when grinding long, small diameter parts that will be sprung or deflected from revolving on their true axis by the pressure of the cut. They help prevent chatter and make it possible to take deeper cuts. The number of steadyrests required depends on the length and diameter of the part. If more than one is used, they are generally spaced from 6 to 10 times the diameter of the work between them. When setting the steadyrests, one should be located in the approximate center of the work, and if more are needed, they should be equally spaced on both sides of the center.

Both work and wheel balance are necessary for accurate work on the centertype grinder, particularly when they cannot be held rigidly in the machine.

The speed of the work is generally from 50 to 100 sfpm; however, on some work that is badly out of balance, lower sfpm is necessary to get a round part. Soft metals and nonferrous alloys grind better at higher work speeds, up to 200 sfpm, where shape and design of work permits.

Traverse speed is limited by the width of the wheel and the finish required. Traverse should never be greater than approximately 3/4 of wheel thickness per revolution of the work for rough grinding, and should be reduced to the speed necessary to produce the finish desired when finish grinding. The length of traverse should never extend beyond the work. In general, the work rpm and the traverse rate can be used to make a wheel act softer or harder as needed. If the work rpm is increased, the wheel will act softer and conversely, if the work rpm is decreased, the wheel will act harder. If the traverse rate is increased, the wheel will act softer, and conversely, if the traverse rate is reduced, the wheel will act harder. In general, as the traverse rate or work rpm is increased, more work is presented to the wheel in the same space

of time. This creates more mechanical stress on the grains of the wheel, causing the wheel to break down faster or act softer. If the traverse rate or rpm is reduced, less work is presented to the wheel in the same space of time. This puts less stress on the grain of the wheel, causing the wheel to break down more slowly and act harder.

To prevent damage to the work and reduce the heat of the grinding operation, most work on centertype machines is ground wet. To get the full benefit from a grinding fluid, it is necessary to keep a good volume of fluid on the work during grinding, with the nozzle adjusted to force the fluid between the wheel and the work.

In centertype cylindrical grinding there are many jobs grinding a diameter and shoulder, holding a radius or fillet to close tolerances, or grinding a flange face with the side of the wheel. Recessing and dishing the side of the wheel will reduce the contact area between the wheel and the work, giving a cooler and freer cut than when using a straight-side wheel.

On a machine where the wheelhead can be swivelled or on a plain machine with a 30 degree or 45 degree angle, this type of operation can be done with an "E" face or an "N" face wheel. Grinding both the diameter and face (shoulder) with the periphery of the wheel, gives a freer cut and better finish with less heat damage to hardened parts than when grinding with the side of the wheel.

Selection of the wheel grade depends on the kind of material (hard or soft), stock removal, finish required, form to hold,fillet or radii, and tolerance. Generally, small diameter work permits use of harder wheels; hardened material requires finer grain and softer wheels. Soft, ductile metals or heavy stock removal or unhardened metals (green grind) require coarse grain sizes. The same wheel can be used to rough and finish by changing the dressing technique. For free cutting or roughing, a fast pass with a diamond dressing tool across the wheel face approximately 0.001 inch deep will open up the wheel face or cut grooves in it, making the wheel act coarse giving good stock removal but poor finish.

If several slow passes are made across the wheel face with the diamond dressing tool with very little infeed, the wheel face will be closed up or seized and the wheel will finish like a wheel several grain sizes finer. However, a wheel in this condition will not remove much stock and could develop chatter if glazed too much. In production quantities of work requiring better than commercial finish and heavy stock removal, it is better to rough with a coarse grit wheel and finish with a fine grit wheel than it is to control finish by dressing.

Center Holes

Centertype grinding relies on the center holes in the part, mating with the precision work centers in the headstock and footstock, to establish an axis of part rotation. The inter-relationship of the center holes and the centers is important for three reasons:

1. It establishes part location and aligns part features, shoulders, etc., with the grinding wheel. This positioning has a direct effect on finished part tolerance.

2. It establishes a true axis of rotation which controls roundness and concentricity.

3. It provides work support, and, therefore, is the first consideration in system rigidity.

Geometry

Center holes should be held as close to 60 degrees as possible, (Figure 1). The depth of the center hole is equally important, for it is these two factors which contribute to proper work center bearing within the center hole. Center hole geometry should always include sufficient relief at the bottom of the hole as well as at its largest diameter. The latter is especially important where the end squareness of the workpiece may vary, or where mass production situations create fluctuations in the center hole depth.

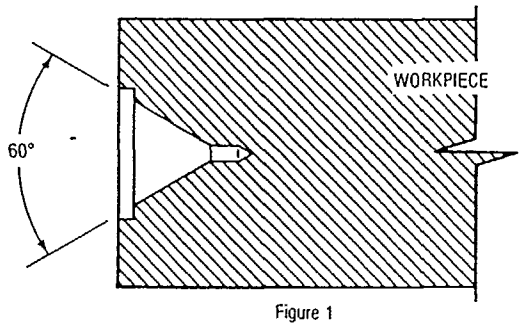


Figure 1

MIL 000130

Squareness

The examples in Figure 2 a, b, c illustrate some proper and improper conditions for center holes. A condition as indicated in Figure 2c would result in an elliptical contact with the work center, thereby seriously affecting part roundness and concentricity.

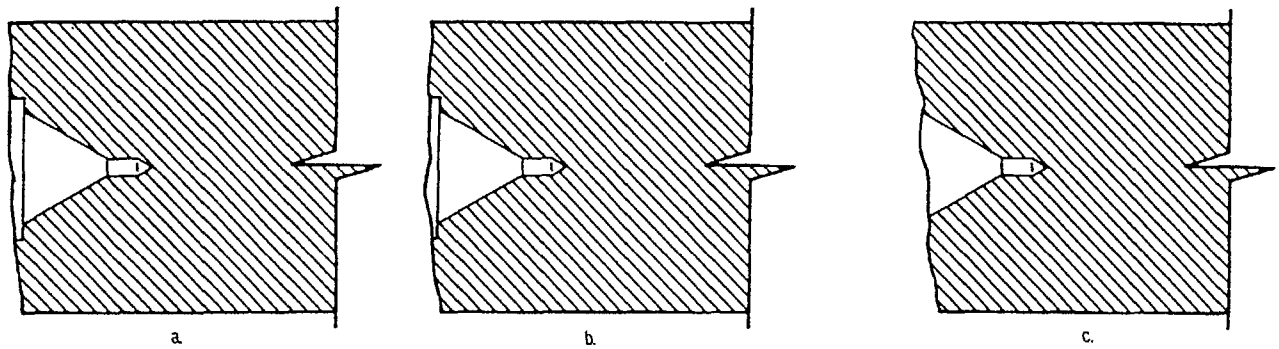


Figure 2

Cleanliness

Cleanliness of center holes is just as critical as the previously mentioned geometry. Any dirt in the contact area can be disastrous. In addition to its affect on part roundness and concentricity, dirt can create serious scoring in the center holes which could jeopardize future operations requiring those holes. There also exists the possibility of work center scoring which could lead to a setup change.

Lapping and Straightening

Heat treating workpieces creates additional problems in part processing. The heat treat operation can easily destroy a center hole, and/or warp a long workpiece. Lapping of center holes following heat treat is always a wise consideration. This operation helps to remove unwanted scale and insures a full circular contact with the work center. Longer parts should be considered for a straightening operation to eliminate warpage.

It is tempting for a process engineer to eliminate center hole lapping or straightening as a cost savings. This will usually turn out to be false economy, since the part roundness can be no better than center hole roundness.

Work Centers

Work center points are usually ground to a slightly larger included angle (60 degrees 15 min.) to insure proper contact with the largest available center hole diameter (Figure 3).

In addition to the accuracy of the points, the accuracy of the work center taper should be carefully monitored. Both points and tapers should be free of nicks, burrs or other imperfections. Centers should be frequently inspected and reground at the slightest indication of a problem.

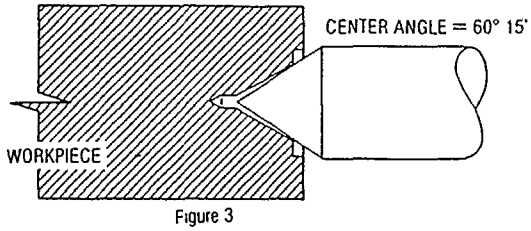


Figure 3

Let common sense prevail in the selection of centers. Never try to hedge on a setup, trying to "get by" with a half-center or other special configuration when the job doesn't call for it. Rigidity of setup, even part holding capability can be seriously undermined by these practices. And, as always, be sure that good engineering practices are followed with regard to specifications for center hole dimensions, as compared to part weight and diameter.

MIL 000131

Centertype Grinding

The two methods of centertype grinding are traverse and plunge. As the majority of applications involve plunge grinding, this is where we will focus our attention.

Plunge grinding involves the straight line feed of the wheel into the workpiece. The application will determine the approach angle, 0 degrees or 30 degrees, which is most practical. The part geometry will also determine the wheel profile, straight or formed.

When simultaneous shoulder/diameter grinding is required, the only efficient processing method to be considered is angular feed. The normal 30 degrees approach angle creates a diameter to shoulder stock removal ratio of 3.5 to 1, therefore, grinding stock on the face and diameter becomes an important consideration for production efficiency.

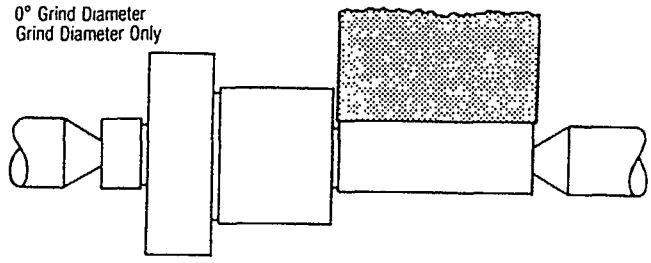
When a condition exists where the length of the shoulder to be ground exceeds the length of the adjacent ground diameter, the wheel angle should be increased to 45 degrees (available only on chucking grinders) to achieve grinding efficiency. Now, however, troublesome differences in wheel surface speed and part rpm becomes a problem. In addition, because of the dressed angle on the wheel and the size of its shoulder, the smallest operating diameter of the wheel is reached after minimal wheel wear.

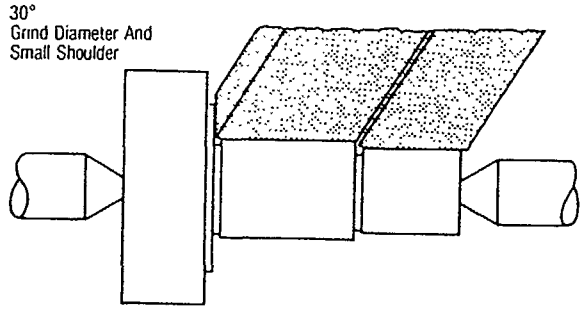
With most plunge grinding applications, a flagging (lateral positioning) attachment is necessary to help maintain the required wheel to part alignment. Any variations in the center hole depth, or fluctuations in shoulder dimensions as the parts come to the grinder necessitates this type of option.

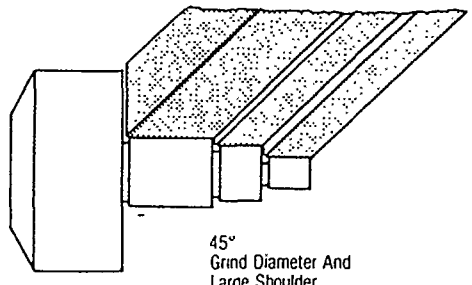
Summary

This issue has only scratched the surface of the subject. The important things to remember are the five criteria, mentioned at the beginning, which help to classify a job as "centertype", and the care required in the production and maintenance of center holes and work centers.

Plunge Grinding







MIL 000132

Problem	Possible Causes	Suggested Correction
1. Chatter marks	Grinding cut too heavy.	Lighter cuts.
	Wheel too hard.	Softer wheel, increase work speed, dress coarser, reduce wheel speed, enrich grinding fluid mixture.
	Wheel out of balance.	
	Slender work unsupported.	Check for vibration within the machine and for vibration transmitted to the machine.
	Machine vibration.	Balance the wheel.
2. Short wave marks.	Vibration from belts.	All these possible causes are corrected by repair and/or replacement of machine components.
	Vibration transmitted from other machines.	
	Vibrations in hydraulic system.	
	Vibration from motors.	
	Vibration from chains and sprockets.	
	Seal in headstock too tight.	
	Imperfect gear action.	
3. Long wave marks	Out of balance wheel.	Rebalance wheel.
	Stopping wheel without turning coolant off, causing unbalanced wheel.	Rebalance wheel and make it a rule to stop coolant and run wheel until moisture is thrown off.
	Wheel oil soaked on one side.	Replace wheel.
	Allowing wheel to absorb moisture from floor.	Store in racks off of floor.
4. Shadows	Grease or oil spots on wheel face.	Redress wheel.
	Hard spots in wheel surface.	Heavily redress wheel or replace wheel.
	Wheel loading.	Redress wheel.
	See long wave marks.	
5. Burlap finish	Loose diamond tool.	Keep tool securely fastened.
	Vibration of diamond tool support	Dampen vibration.
	Uneven table traverse when truing.	Check hydraulic system.
6. Diamond Truing Lines	Diamond too sharp.	Try a duller diamond.
	Table traverse too fast.	Slow table speed.
	Wheel too hard.	Try softer wheel or make act softer. (See #1 above.)
7. Feed lines	Wheel not suitable.	Change wheel.
	Improper control of traverse or work speed when finishing.	Change work speed or wheel speed when finishing.
	Improper coolant distribution when truing.	Readjust coolant flow and direction.
	Improper use of steadyrests.	Ensure steadyrests are even.
	Head or footstock out of alignment.	Check head and footstock, tableways and center holes.
8. Barber pole finish	Improper lubrication of tableways.	Adjust oil flow or change oil.
	Work loose on centers.	Be sure head and footstock are properly clamped.
	Centers do not fit spindles.	Check centers for fit.
	Loose fitting footstock spindle.	Obtain new footstock spindle.
9. Burnt Work and cracked surfaces	Wheel too hard.	Try softer wheel or make act softer.
	Wheel structure too dense.	Try more open structure wheel.
	Wrong wheel bond.	Consult Cincinnati Millacron Marketing Company Sales Representative.
	Grinding wheel over speed.	Reduce speed.
	Work revolving too slowly.	Increase work speed.
	Grinding cut too heavy.	Rough and finish grind with two wheels.
	Insufficient coolant.	Check coolant level, pipes and pumps.
	Nozzle not directing coolant properly.	Redirect flow or obtain new nozzle.
	Wrong coolant.	Consult Cincinnati Millacron Marketing Company Sales Representative.
	Grinding wheel improperly trued.	Redress wheel.

Problem	Possible Causes	Suggested Correction
10. Rough finish	Wheel too coarse or too hard. Diamond too sharp. Dressing too coarse. Cut too heavy. Traverse too fast. Work speed too fast. Lack of proper steadyrest. Dirty coolant. Solution of coolant too weak.	See above suggested correction.
11. Uneven wheel surface.	Rapid diamond wear. Improper distribution of coolant. Diamond tool holder not securely clamped. Table floating.	Change to larger diamond. Readjust coolant flow and direction. Securely fasten holder. Reduce lubricant flow to table or change to a lighter oil.
12. Out-of-round work when plunge grinding	Workpiece centerholes out of round or not in line. Burrs in workpiece center holes. Work loose on centers. Centers loose. Centers do not fit spindles. Center holes out-of-round. Workpiece center holes not deep enough. Work centers scored. Center points worn down. Work too tight on centers. Insufficient coolant. Worn footstock spindle. Misalignment of workheads. Swivel table gibs loose.	Relap center holes. Clean holes. Be sure footstock & headstock are clamped. Tighten and clean centers. Replace spindles or change center holes. Regrind center holes. Deepen holes or blunt center points slightly. Regrind centers and lubricate. Regrind centers. Loosen footstock spring tension. Readjust coolant flow. Replace spindle or use steadyrest close to footstock. Realign workheads. Be sure gibs fit and clamp swivel table securely.
13. Intermittent cutting action while traverse grinding	Heavy work too tight on centers. Work out of balance. Base high in middle or at one or both ends.	Back off footstock .002 to .004. Add weights to balance workpiece. Realign or possibly rescrape base.
14. Adjacent diameters of work not concentric.	Work loose on centers. Centers not in alignment on workpiece. Headstock or footstock moving away from work. Centers do not fit spindles. Base out of alignment.	See above for suggested corrections.
15. Unable to keep work straight	Headstock or footstock out of alignment and center holes of varying depth.	Correct alignment and/or regrind centers.

Common Dimensional Standards

It is not possible to list the exact sizes of wheels for all of the various models of cylindrical grinding machines, because the size depends upon what wheel and what size wheel guard are on the machine. The only way to be certain of the size is to measure the wheel, the guard, the wheel collet or all three, if you need to.

For further information write Cincinnati Milacron Marketing Company Abrasive Applications Dept., or contact your local Cincinnati Milacron Marketing Company Sales Representative.

MIL 000134

Starting Grade Recommendations

Specification Selection Guide

Application	Wheel Specifications
Production Grinding:	
Automotive (cast alloys and forgings)	
roughing	97A601-N4-VFME
finishing	97A801-J4-VFME or 9A80-J4-VFME, or 97801-09-B2
roughing and finishing (hand machine)	97A801-P9-B2
finished bearings	97A701-M4-VFME, or 6C60-L4-VSCE
dual cycle (rough and finish with same wheel on same machine)	97A701-N4-VFME
Automotive (hardened steel)	
roughing	97A601-L4-VFME
finishing	C12A801-N9-B2
Cast Iron	
roughing	97A701-N4-VFME
finishing	97A801-L4-VFME
dual cycle	97A701-M4-VFME
Chilled Iron	
roughing	97A541-L4-VFME
finishing	97A701-K4-VFME
Diesel and truck hardened forged shafts	
roughing	97A601-K4-VFME
roughing (100%) burn free)	9A70-I6-VRWE
finishing	9A80-H6-VFME C2A801-P9-B90
rough bearings	2A54-L6-VFME
finishing bearings	97A801-L4-VFME

Application	Wheel Specifications
Regrinding	97A801-N4-VRWE
Cast Iron	9A70-L4-VFME
Chilled Iron	9A60-L4-VFME
Spheroidal graphite iron	97A601-M4-VFME
Steel	
roughing	97A541-N4-VFME
finishing	97A801-L4-VFME
Steel (hardened)	9A60-K4-VFME
Wide Lobes	
roughing	29A601-K6-VAE
finishing	29A801-J4-VAE
Narrow Lobes	
roughing	97A601-M4-VFME
finishing	29A801-K4-VAE
Ceramic (MSB)	
Most Lobes	
roughing	3MSB601-K4-VSAE
finishing	3MSB801-J4-VSAE

For wheel speeds over 8500 SFPM, on vitrified applications, contact your Cincinnati Milacron Marketing Company Sales Representative.

To use VQC or VRW, go one grade softer.

5

Starting Grades

Narrow Lobe - 97A701-M4-VFME

Wide Lobe - 97A601-I6-VFME

A high volume of a good quality coolant is a necessity in cam grinding, i.e., CIMCOOL 400 or CIMPERIAL 20.

As most cam grinding machines are custom fitted to the part being ground, it is impossible to properly specify a wheel without certain information. Before ordering any cam wheel, be sure to accurately obtain:

The machine model and serial number.
The actual spindle speed, roughing and finishing.
The wheel size. (A blueprint would be helpful.)
The current specification in use.

PLEASE ADJUST COOLANT NOZZLES A MINIMUM OF FOUR TIMES PER SHIFT

One of the most common causes of burn on cam grinding operations is failure to keep the coolant nozzle close to the wheel. the intermittent dressing over a 2 hour period causes the grinding face to move away from the coolant nozzle thus we get burn.

MIL 000135

Cam Grinding

Cam grinding is another special class of cylindrical grinding and is unusual in that, because of the eccentric shape of the cam, the ratio of the workpiece surface speed is always varying in relation to the wheel surface speed. Depending upon the shape of the cam, the workpiece surface speed can vary greatly.

To compensate for this variance the wheel must be as free cutting as possible. This is especially true at the time when the nose of the cam has passed the wheel and is turning away. A wheel that is not free cutting will enlarge on the turning-away motion by adding some push of its own which can produce an out-of-shape cam. On the other hand, the wheel must be chosen for durability, because the irregularity in work surface speed tends to abuse the wheel face; this can be amplified by poor machine condition.

Production cam grinding is found in the automotive, aircraft, truck, ship-building, locomotive and farm equipment engine industry. Two types of installations are found: 1 Dual cycle machines which rough and finish with one wheel specification, and 2 Two separate machines - one for roughing and one for finishing. In the first case, special high speed vitrified wheels are normally used: in the second, standard vitrified wheels are used for roughing and resinoid or rubber wheels are used for finishing.

Cam regrinding is found in engine rebuilding shops throughout the country. The amount of material which must be removed is less than in original manufacture, but the same critical shape tolerances apply.

Type 1 wheels, 24 inches in diameter with thickness ranging from 1/2 to 2 inches are most common. Aluminum oxide abrasives, in grit sizes 46 to 120, are used in vitrified, resinoid and rubber bonds. Grades I6 thru N4 vitrified and K9 thru S7 resinoid are also used.

Typical Machine Manufacturers

Landis Norton Warner and Swasey

Landis Tool Co., Waynesboro, PA

Machine/Model	Capacity	Wheel Size	MOS/SFPM	
5R-1W	14 x 36"	42 x □ x 12	8500	
Multi-Wheel	16 x 48"	42 x □ x 12	8500	
Grinder	10 x 36"	36, 42 x □ x 12	8500	
			Rough	Finish
Type S (Dual Cycle)	5 x 30"	18 24 x □	12,000	6,000
Cam Control		x 12 050		
Grinder	5 x 26"			
	5 x 30"	24 x □ x 12		
Type R	5 x 40"			
Cam Grinder				
		24 x □ x 18		

Norton Company, Worcester, MA

Machine/Model	Wheel Size	MOS/SFPM
CAM-O-MATIC	24 x 7/8 x 18	6500
#1, #2, #3	24 x 1 x 18	6500
	24 x 1 1/4 x 18	6500

Warner and Swasey, Worcester, MA

Machine/Model	Wheel Size	MOS/SFPM
#3 CAM-O-MATIC	24 x □ x 18	8500 or 10,000
CAM-MASTER	various	
#4 CAM-O-MATIC	24 x □ x 16 050	10,000

†Any combination up to 30" including spacers.

Basic Principles

*It is obvious that the complexity of generating cam shapes by grinding demands that the machine be in very good condition. When conditions such as these exist, some variation in grain and grade can improve the results, but wheel produced chatter will normally show all the way around the cam periphery. Also, if the wheel is affecting one ramp contour, it should affect both. It is a good idea to check the machine before changing the wheel specifications.

When testing specifications, do not attempt to judge the wheel on lobe shape generated, as this is strictly a function of the master cam. The master cam itself may have to be altered, particularly if changing from vitrified to resin wheels or vice-versa. The wheel itself should be judged on the stock removal rate, G-ratio, lobe-to-lobe size control, freeness of cut, etc.

Trouble Shooting

Problem	Possible Causes	Suggested Correction
1. Chatter on cam nose.*	Interference of rocker bar motion.	Sludge jamming motion, clean or replace.
	Scored bearings	Check for irregularities in rocker bearings.
	Insufficient lubrication.	Tight bearings in rocker bar — lubricate.
2. Irregular ramp contour*	Interference of rocker motion.	Sludge jamming motion or scored bearing; clean and/or replace; lubricate.
	Loose bearings	Check bearings for excessive wear
	Insufficient contact between master cam and follower.	Ensure positive contact between masters
3. Poor quality of grind	Wheel too coarse	Use finer grit wheel
	Wheel too hard	Use softer grade of grinding wheel.
	Poor quality of dressing	Ensure quality diamond and dress technique
	Dirty coolant	Ensure clean coolant and filter regularly
	(also, see Cylindrical Grinding)	

Starting Grade Recommendations

Specification Selection Guide

Application	Wheel Specifications		
Airplane Crankshafts			
pins	97A461-K4-VFME	29A461-L4-VFME	3MSB541-K4-VSAE
bearings	97A701-L4-VFME	29A701-M4-VFME	3MSB601-K4-VSAE
Automotive crankshaft (pins & bearings)			
roughing:			
heavy side removal	97A461-O4-VFME	97A601-N4-VFME	3MSB541-M4-VSAE
light side removal	97A541-N4-VFME	29A601-L4-VFME	3MSB5601-K4-VSAE
finishing	97A701-K4-VFME	29A701-L4-VFME	3MSB801-J6-VSAE
roughing and finishing	97A701-K4-VFME	29A701-L4-VFME	3MSB541-L4-VSAE
regrinding	97A701-K4-VFME	29A701-L4-VFME	3MSB801-J4-VSAE
Automotive pins	2A54-N4-VFME	97A541-M4-VFME	3MSB601-K4-VSAE
forged steel	97A701-O4-VFME	97A601-N4-VFME	3MSB601-K4-VSAE
nodular iron	97A701-O4-VFME	971601-N4-VFME	3MSB601-L4-VSAE
Cast Iron			
pins	97A601-M4-VFME	29A701-L4-VFME	3MSB601-K4-VSAE
bearings	97A701-M4-VFME	29A701-L4-VFME	3MSB601-K4-VSAE
center thrust bearings	97A701-M4-VFME	29A701-L4-VFME	3MSB601-K4-VSAE
Diesel crankshafts			
before nitriding	97A601-K4-VFME	29A601-L4-VFME	3MSB601-K4-VSAE
after nitriding	97A701-K4-VFME	29A601-L4-VFME	3MSB601-K4-VSAE
Multi-wheel arrangements (bearings)			
Steel (nitrided)			
pins	97A601-N4-VFME	29A701-N4-VFME	3MSB601-L4-VSAE
bearings	97A701-N4-VFME	29A701-N4-VFME	3MSB801-K4-VSAE
center thrust bearings	97A701-K4-VFME	29A701-K4-VFME	3MSB801-J6-VSAE
Steel (induction hardened)			
pins	97A541-M4-VFME	29A601-M4-VFME	3MSB601-M4-VSAE
bearings	97A601-N4-VFME	29A601-N4-VFME	3MSB801-K4-VSAE
center thrust bearings	97A601-O4-VFME	29A601-N4-VFME	3MSB801-J6-VSAE
Thrust Walls	97A541-N4-VFME	29A541-M4-VFME	3MSB601-K4-VSAE
Transfer pin grinders - dress each pin	97A601-M4-VFME	29A541-M4-VFME	3MSB601-L4-VSAE

For wheel speeds over 8500 SFPM, contact your Cincinnati Millacron Marketing Company Sales Representative for recommendations.

To use VQC or VRW, go one grade softer.

MIL 000137

Basic Principles of Crankshaft Grinding

Wheels for crankshaft grinding are purposely oversize in thickness, and the additional stock is dressed away by the customer to the required size, usually given with a decimal tolerance.

These wheels are speed tested and marked for operation at speeds higher than 6500 SFPM. Your Engineering data sheets and order entry forms must specify "Crankshaft" or "Camshaft" wheels if you want delivery of the wheels marked with the higher operating speeds.

There are many diameters of wheels used on crankshaft grinders but the 42" diameter has been found to be the mos popular size.

Crankshaft grinding is a special class of cylindrical grinding which is one of the most severe precision jobs that will be encountered. Not only must large amounts of stock be removed from the pins and bearings as well as from the sidewalls by plunge grinding, but dimensional accuracy, corner radii and surface finish must be maintained.'

Most crankshaft wheels are Type 1, ranging from 24 to 60 inches in diameter and 1/2 to 6 inches thick. Cincinnati's diameter limitation is 42". Very often customers will specify special thickness dimensions that conform to the mean width of the pin or bearing. Always specify tolerances on thickness to be sure that the wheel, as ordered, is at least .031 thicker than the pin or bearing width, to allow for truing allowance and assure true running sides.

Some of the thicker wheels may be relieved or recessed to wheel Types 5, 7 or 21. Aluminum oxide abrasives in vitrified bond are predominantly used. Grit sizes 36 to 80 in grades J thru Q cover most of the range.

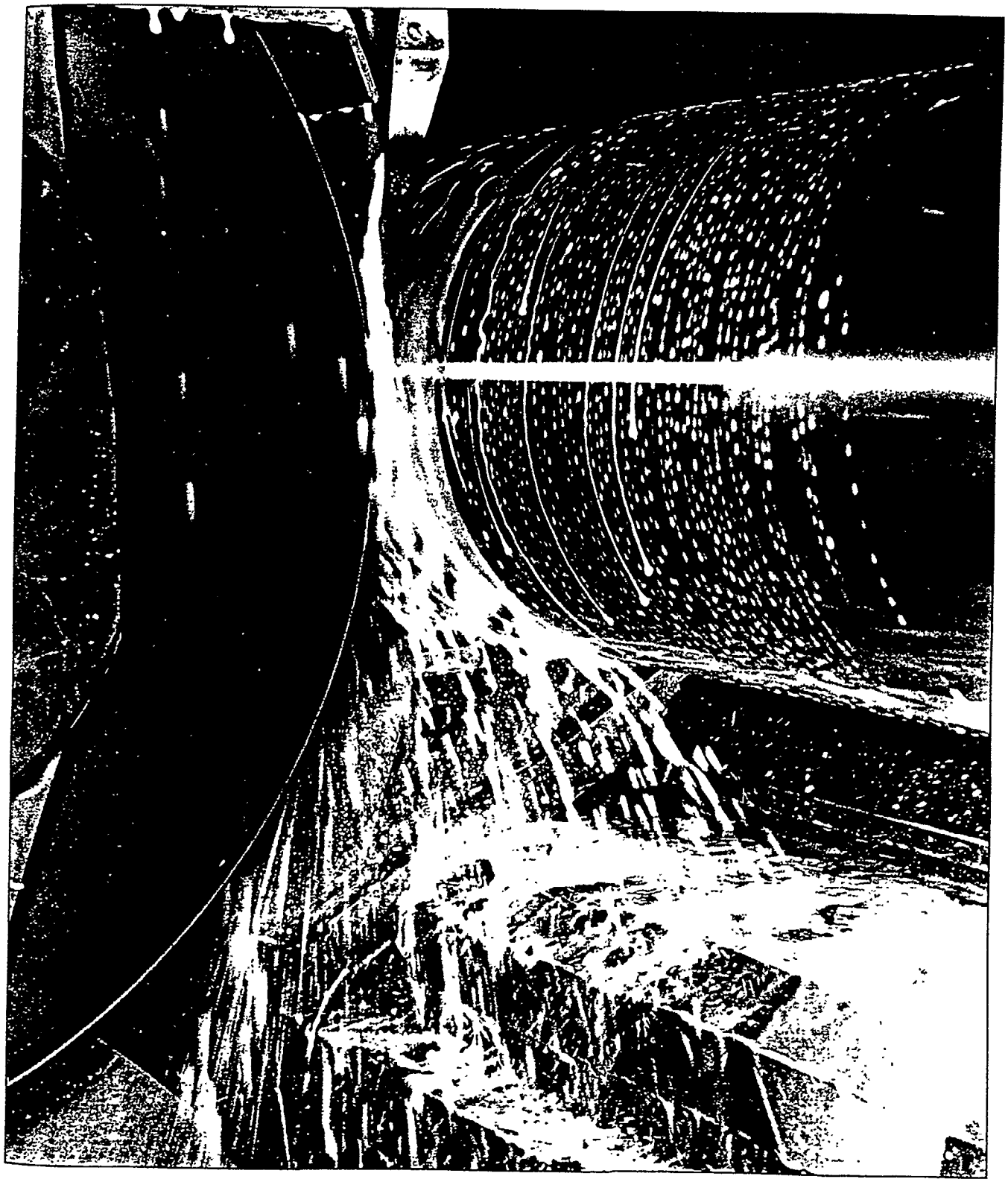
Crankshaft grinding is found throughout the automotive, truck, diesel, aircraft, small engine manufacturing industry and also in many engine rebuilding firms for regrinding of the pins and bearings. Wheel speeds of up to 8500 SFPM are most common, however, some newer production machines will run at higher speeds. If in doubt of which specifications can be used for the speed required, contact your Cincinnati Milacron Marketing Company Sales Representative.

Trouble Shooting

Problem	Possible Causes	Suggested Correction
1. Poor Finish	Wheel too coarse or too soft.	Use harder grade and/or finer grit. Use sharp, rigidly held diamond dressing attachment with point contact below center.
	Improper wheel dressing.	
2. Flats generated on diameter	Wheel too hard. Wheel out of balance. Steady rest deflection.	Use softer cutting wheel. Balance wheel. Ensure rigid steady rest.
3. Chatter in radii	Dull diamond in radii attachment.	Check and replace.
	Work head speed too high.	Slow work head speed.
	Too high stock removal.	Reduce stock removal rate.
	Poor quality coolant.	Increase lubricity of coolant.
4. Thrust face poor geometry (stepped/taper)	Wheel too soft.	Use harder acting, better corner holding wheel.
	Wheel speed too low.	Increase wheel speed, check correct pully.
	Tapered wall wheel too hard.	Use softer acting wheel.
5 Thrust face burning	One side burning - poor diamond dress.	Redress and/or redress at increased infeed.
	Both sides burning - poor diamond dressing.	Use corner diamond dress & check for worn diamond.
	(also, see Cylindrical Grinding)	

NOTES:

6 Precision Roll Grinding



Introduction

Roll grinding is a specialized form of cylindrical grinding requiring considerable skill since it is precision grinding of a high caliber.

Roll grinding wheels are used to grind rolls which are tools used for shaping many types of materials such as steel, copper, aluminum, tin, paper, paint, ink, etc. Unless the rolls are ground accurately, it is impossible to produce rolled steel strip or aluminum sheet of the required quality. The finish on the rolled material can never be better than the surface of the roll itself, and unless the roll is ground accurately with respect to straightness, (or crown) the gauge of the metal being rolled will not be uniform. The present day trend in roll grinding is toward closer tolerances and high finishes. The trends challenge not only the wheel manufacturer but the machine builder and the machine operation as well. Without the skill of the operator, no grinding wheel will produce the desired results, while on the other hand, without the right wheel, an operator, no matter how skilled will have trouble. What must be realized is that the best grinding wheel made is of little value when used on the wrong job or application even though diverse cutting characteristics can be given a wheel by skillful manipulation, with relative speed of the work, traverse and wheel. A skillful operator can, by manipulation of controllable factors, compensate for deficiencies in wheel size and grade.

The Roll Grinding Machine

Roll grinding machines are basically large powerful cylindrical grinding machines of very sturdy construction to assure minimum vibration when grinding. Conventional roll grinding machines range in size from 10" to 80", this dimension designating the maximum outside diameter of the roll it will accommodate. The 28", 36", 48", 60" and 80" machines are commonly used in steel and aluminum plants. Most machines use 36 x 4 x 20 or 36 x 4 x 12 inch wheels although thickness of these wheels can range from 2 to 6 inches and diameters from 20 to 42. Rolls are generally ground by supporting them on their necks, and journal rests may be either brass, iron or babbit. The roll drive is generally of the universal type to insure uninterrupted and smooth rotation. Most machines allow the wheel traverse, wheel speed and roll speed to be varied allowing the operator to vary each to obtain the best grinding results. By referring to the ammeter, the operator can obtain the highest rate of production possible and learn at what point the wheel is working at its maximum efficiency. Because it is necessary to crown many of the rolls, these machines have attachments that make it possible to grind either a crown or concave on the roll. The initial cost of roll grinding machines and high quality work they must produce makes it very important that they be kept in excellent condition mechanically at all times.

The Roll Grinding Wheel

What is the definition of the perfect roll grinding wheel?

The perfect roll wheel:

1. Will never wear out.
2. Will produce a finish which meets the RMS specified by the rolling mills.
3. Will remove the necessary stock in one or two passes and always get beneath any chatter and eliminate it in one pass.
4. Will require no dressing.
5. Will perform all the above functions day after day in summer and winter with exact consistency.

The cutting action of a wheel depends upon (1) the kind of abrasive used, (2) the size of the abrasive grain, (3) the bond that holds the abrasive grains together, and (4) the spacing of the abrasive grains in the bond.

We, at Carlisle, Pennsylvania, as in most other grinding wheel companies, specify and design grinding wheels by volume structure. For example, a wheel might have 52% abrasive by volume, and 16% of a bonding agent by volume which adds up to 68% leaving 32% of the wheel as voids or simply air. Such a wheel would be a K grade and in a 6 structure. So the grade is simply an indication of the amount of bond holding the abrasive grain. The more bond in the wheel, the harder the wheel will act. As we increase the grade, the voids in the wheel become less. So, if we keep the abrasive at 52% by volume, but go to 18 bond by volume, we reduce the voids to 30% and the wheel will act harder. Here the wheel will be an L grade, 6 structure.

If we are grinding soft material and want more chip clearance, we may want wider grain spacing or less volume % of abrasive per wheel. So we might change to 48% abrasive by volume. To keep the grade the same as the L grade we just mentioned, we will have to keep the voids at 30%, so our bond content would increase from 18 to 22% by volume. The wheel here would be an L grade, 8 structure.

The grinding wheel, in theory, and to some degree in practice, is self-sharpening. Grains fracture and present new cutting edges so when dulled or worn down badly, they are torn out of their setting and so allow other grains to come into play. When an abrasive grain starts to enter and penetrate the work as the wheel and work revolve, the depth of the cut gradually increases to a

maximum somewhere along the arc of contact, and since the wheel usually rotates much faster than the roll, the greatest depth of cut is very near the spot where the wheel leaves the work.

The two key components in any grinding wheel are the grain and the bond. The two most commonly used types of grain in roll wheels are aluminum oxide and silicon carbide. Most iron rolls use silicon carbide and steel rolls use aluminum oxide. Depending on the type of roll being ground and the finish required, aluminum oxide can be supplied in a variety of friabilities or toughnesses. The abrasive grains can each be furnished in at least 32 different sizes and in most cases, two or three sizes of abrasives are used in each specification. Structures and grades have a wide variety of combinations and are usually tailored to the particular application.

Turning to the other major component, bonds, there are mainly four different types of bond used in roll grinding: (1) Resinoid; (2) Shellac; (3) Epoxy; and (4) Vitrified.

Although there are only two key components in a roll wheel, there are literally thousands of different combinations that can be produced. Therefore, careful consideration must go into specifying the wheels. Some of the factors that must be considered to choose the right wheel are:

1. The kind of material being ground: iron, steel, rubber, etc.
2. The amount of stock to be removed; accuracy and finish required and rate of production desired.
3. Type and condition of the machine.
4. Size of the wheel and arc of contact between the wheel and the roll.
5. The skill of the operator.

Harder grade wheels may be employed to an advantage for heavy stock removal on sturdy machines which are equipped with generous size wheel spindle bearings and motors. Small diameter wheels work better on large diameter rolls due to a narrower arc of contact, allowing the abrasive grains of the wheel face to properly penetrate the hard roll surface and readily remove stock.

Besides the variables of the wheel itself, there are a great many other variables that can affect the wheel. Many of these variables can be controlled by the operator and can make the difference between a wheel that works and one that doesn't. Some of these variables are:

Work Speed — By changing the speed that the work is rotating, a skilled operator can change the way the wheel will act when cutting. If the wheel is acting too hard, an increase in the speed the roll is turning can make this wheel act softer. If the wheel is acting too soft, decreasing the roll speed will cause the wheel to act harder.

Wheel Speed — It must be emphasized here that the wheel should never be run over the maximum operating speed specified by the wheel manufacturer. But by changing the wheel speed, the cutting action of the wheel can be changed. For a wheel acting too hard, reducing the speed of the wheel will make the wheel act softer and increasing the speed of a soft wheel will make it act harder.

Traverse Speed — If the rate of traverse is increased, a hard wheel will act softer but the finish of the wheel will be rougher. If the traverse rate is decreased on a soft wheel, the wheel will tend to act harder and give a better finish.

Wheel Dressing — Varying the type of dress, the same wheel can be used for roughing and finishing. When dressing the wheel for roughing, a quick pass across the face of the wheel will leave a rough surface sufficient for most roughing operations. Redressing the wheel very slowly across its face will produce a wheel that is suitable for finishing operations on the rolls.

The grinding of rolls is done with a constant stream of fluid ideally directed at the point of contact between the sheet and the roll. Wet grinding is done because the material used to bond the abrasive grain in roll wheels breaks down under the heat of grinding. So the grinding fluid helps slow this breaking down by acting as a coolant. Water is the best coolant and some mills use it right out of the lake onto the work. But the problem with water is that it tends to rust the rolls. Soluble oils used with soft water has the advantage of not rusting the rolls and also reducing friction between the wheel and work thus improving the grinding action. But soluble oil must be neutral - neither alkali or acidic to prevent damage to the wheel. Soluble oil mixed too rich can cause a wheel to gum up. Detergent solutions keep the face of the wheel clean but sometimes keeps the wheel cutting so well that good finishes cannot be produced. Each mill selects one or a combination of grinding solutions depending on its own requirements and developed grinding practices.

As with most wheel manufacturers, Cincinnati Milacron Resin Abrasives has very strict quality and manufacturing standards that follow throughout the entire manufacturing process. These standards run from the testing of raw materials to the final shipping of the product.

Now that we have briefly covered some of the basic principles of roll grinding, let's look at some of the various types of rolls that are ground with these wheels.

Hot-Strip Mill Rolls

The sheet rolling process starts in the hot strip mills where slabs of metal are rolled into sheets. Rolls of this sheet metal are then stored to be rerolled to a finished thickness in a cold mill. These work rolls are usually 20" to 30" in diameter and up to 130" long. They are commonly called "chilled iron rolls" which are usually nickel grain or nickel chill castings, alloyed with chrome nickel an molybdenum. Here the typical abrasive would be silicon carbide. Because the finish of these rolls is not too critical, a 36 or 46 grit wheel would be recommended. The rolls often come into the roll shop in bad condition and stock removal of .030 to .040 is often required. Here the preferred wheel would be a fairly free cutting wheel in a J or K grade with fairly wide grain spacing to remove the stock rather quickly. The bond by choice in this wheel would be a resinoid bond.

Cold-Strip Mill Rolls

There are various mills that cold roll the steel to its finished size. Some of these are temper mills, tandem mills, skin mills, tin mills and other but most of these use forged steel rolls usually 25" to 30" in diameter. Because the finish on these rolls is transmitted to the finished product, it is important that these rolls be chatter free, with no scratches, traverse lines or other surface imperfetions. The typical specification here would be an aluminum oxide 80 grit wheel with a resin bond in a J or K grade. If the finish and dimensional accuracy is extremely important, then we might specify an 80 grit shellac wheel. Where even finer finishes are needed, 150 grit might be used.

Back-Up Rolls

Back-up rolls in both the Hot Strip Mills and Cold Strip Mills are larger in diameter than the work rolls. These rolls are usually about 60" in diameter and as long as 154". Back-up rolls are usually steel with a few being cast iron. These rolls are usually ground with a 24 grit aluminum oxide wheel. The bond in this type of wheel is normally a resinoid bond but in some cases the use of shellac and epoxy has proven successful.

Paper Mill Rolls

Paper mill rolls require frequent regrinding. These rolls ae relatively small in diameter in comparison to their length, a typical size being 11-30" in diameter and 120 to 250" long. These rolls are usually chilled iron with a few steel and some rubber. These machines usually use 2 wheels 20" in diameter, one in the front of the roll and the omer in the back of the roll. The usual specification here is a very open silicon carbide shellac wheel in the 36 to 60 grit range for the chilled iron. A good choice for a rubber roll would be silicon carbide 24 grit I or J grade in a resin bond.

The Roll Wheel

Cutting action depends on:

1. Kind of abrasive
2. Size of abrasive
3. The bond that holds the grains together
4. The spacing of the abrasive grain

General rules:

1. Always start with silane coated
2. Brown A/O for most steel
3. White and brown for chrome and exotics
4. S/C for iron rolls
5. The coarser the wheel, the harder it will act

Hot Strip Mill Work Rolls

- Rolling hot steel into sheets
- Called chilled iron rolls
  - — Ni grain or Ni chill castings
  - — Alloyed with chrome nickel and Molybdenum
- Shore 60 - 85
- 20 to 30" diameter, 24 to 132" length
- Crowned rolls
- Commercial finish
- .015-.040 removal
- Material usually rerolled
- Open S/C wheel
- Free cutting J or K grade
- Resinoid - B320 or B90 Bond

Hot Strip Mill Back-Up Rolls

- Used for added pressure while rolling
- Cast alloy or forged steel
- 60 to 80 Shore
- Larger - up to 60" diameter, 30" length
- Must be straight and accurately ground
- 24 to 46 grit A/O wheel, Resin
- J or K grade, B320, B90 Bond

Cold Strip Work Rolls

- Steel rolled to finish size
- Tempermills, Tandem mills, Skin mills, Tin mills
- Mostly forged steel - some iron
- 25 to 30" diameter
- Harder - 70 to 100 Shor
- Finish critical
- Typical 80 grit shellac or epoxy
- A/O or combination H5A
- Also use of some resin B6959
- Shellac preferred on work rolls
  - stay sharp
  - free cutting

Bond Type B320

- Straight resin product
- Used for most applications
- Good on old machines
- J thru L grades most common
- 24 thru 80 grit A/O or S/C

Bond Type B90

- Straight resin
- Used for coarser grit 24, 36, 46, 60
- Modified resin
- Good for roughing wheels
- H thru N grade
- 24 to 60 grit, A/O or S/C

Bond Type BM-6959

- Straight resin
- S/C filler
- Usually used in softer grades
- Coarser grits
- H thru L grades most common
- 24 thru 46 grit
- B320 acts approximately 2 grades harder than B90

Bond Type Shellac

- Straight shellac
- Used where finish is critical
- Extremely hard material
- I thru L grades most common
- 24 thru 180 grit, A/O or S/C

Bond Type Epoxy

- Straight epoxy
- Substitute for shellac
- Used where resin is too hard, shellac is too soft
- Good for older machines where resin bounces
- Usually H thru K grades
- 24 thru 100 grit, A/O or S/C

How To Make A Wheel Act Harder

1. Decreasing the work speed
2. Decreasing the traverse speed
3. Decreasing infeed/downfeed
4. Increasing the wheel speed while observing proper safety procedures
5. Dressing at a slower traverse rate
6. Using a lighter dressing feed

How To Make A Wheel Act Softer

1. Increasing the work speed
2. Increasing traverse speed
3. Increasing infeed/downfeed
4. Decreasing the wheel speed
5. Dressing at a faster traverse rate
6. Dressing the wheel face thinner
7. Increasing the depth of dress per traverse
8. Dressing more often

Functions of Grinding Fluids

- Cooling, protects the workpiece.
- Lubrication allows for "'Cool" cutting.
- A reduced loading wheel cuts cooler.
- Swarf may harm the finished surface.
- Corrosion is bad for workpiece, fixturing, machine tool, etc.
- Transparent fluid for visual control of grinding pattern in roll grinding.

Advantages of Using Grinding Fluids

The proper selection and application of the RIGHT grinding fluid can substantially increase productivity by reducing cycle time by as much as 50 percent.

- Higher grinding speeds and infeeds
- Longer wheel life
- Lower power consumptions
- Better surface finishes
- Closer dimensional control

Types of Grinding Fluids

There are two basic types of grinding fluids:

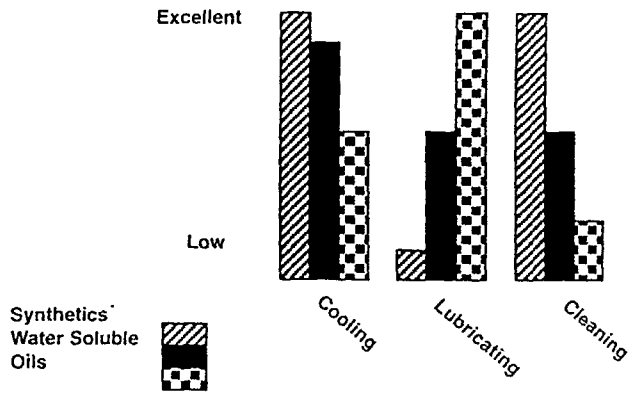
- Grinding Oils
  - Straight mineral or fatty oils
  - Compounded oils (plus additives)
- Water-miscible (water soluble) fluids
  - Emulsifiable oils (soluble oils)
  - Chemical (synthetic) fluids
  - Semichemical (semisynthetic) fluids

Waterbase Grinding Fluid Composition

A list of several items or additives that may make up a typical water-miscible grinding fluid:

- Oils and water are usually the main ingredients.
- Extreme pressure additives help lubrication.
- Emulsifiers keep the oil suspended in the water.
- Bactericides destroy unwanted bacteria.
- Anti-foaming agents stop frothing.
- Corrosion inhibitor prevents rust.
- Chemical lubricants reduce the need for oil.
- Other additives such as water treatment may be added.

Grinding Fluid Comparison



These bar charts compare the relative performance of the three basic types of grinding fluids in terms of their ability to cool, lubricate and clean.

- Synthetics are excellent for cooling and cleaning but have low lubricating qualities.
- Water soluble runs about in the middle for all three functions.
- Straight oil is excellent for lubrication, average for cooling and has poor cleaning qualities.

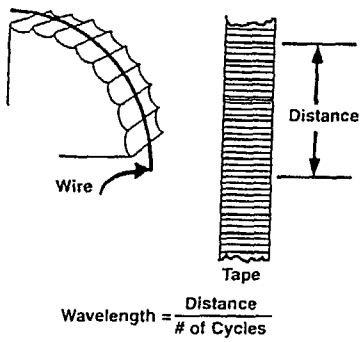
The "G" Ratio

G = Grinding Ratio. The amount or volume or wheel wear in comparison to the amount of workpiece material that has been removed during the grinding process.

$$\text{"G"} = \frac{\text{Volume of Material Removed from Workpiece}}{\text{Volume of Wheel Worn Away During Grinding}}$$

MIL 000144

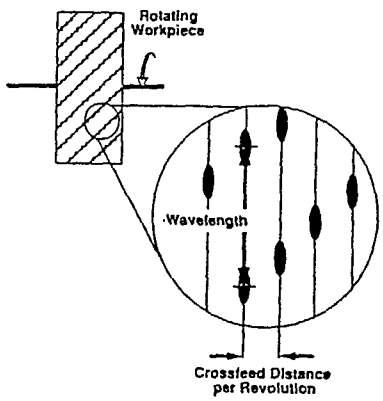
Straight Line Scallops Across Face of Part



Scallops are usually very shallow - measured in millionths.

- Often need good light to see clearly.
- Various frequencies may be overlaid.
- Use Talyrond or wire and lift with tape.
- Count the number of complete cycles in a selected distance for a good estimate of wavelength rather than try to measure width of a single cycle.
- Usually seen in plunge operations without crossfeed.

Spiral



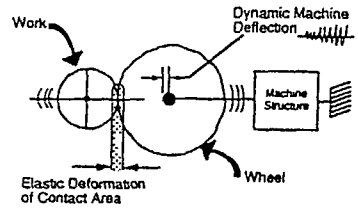
Usually present where there is crossfeed.

- Spiral pattern is actually pattern of short scallops which shift with successive workpiece revolutions.
- Wavelength is distance between successive scallops - measured as shown.

Importance of Chatter-Vibration Marks On Product Performance

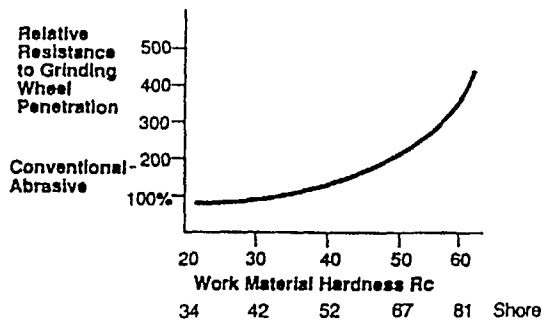
- Unsightly, suggests good grinding practice was not being used.
- May create audible noise when product is run at high speed.
- Occasionally results in premature part failure usually as the result of fatigue.
- May disrupt lubrication
- Chatter standards should be set on basis of scallop height measurement

Regenerative Chatter - Vibration



- Regenerative chatter is a very important form of self-excited vibration.
- Word "chatter" is usually used by vibration experts to designate self-excited, regenerative type vibration.
- Bumps may develop on wheel and work which become progressively larger with time
- Frequency of chatter depends upon resonant (natural) frequencies of the grinding system

Resistance to Grinding Wheel Penetration Increases with Increased Work Material Hardness



This graph shows that as you approach 50-60 Rc it gets very difficult to cause the grinding abrasive to penetrate into the surface of the workpiece. This results in very thin chips and considerable machine deflection, particularly for weak grinding systems. Some of this behavior is due to the fact that the wheel itself flattens out in the contact area — sort of like the way a tire flattens against the road due to the weight of the car.

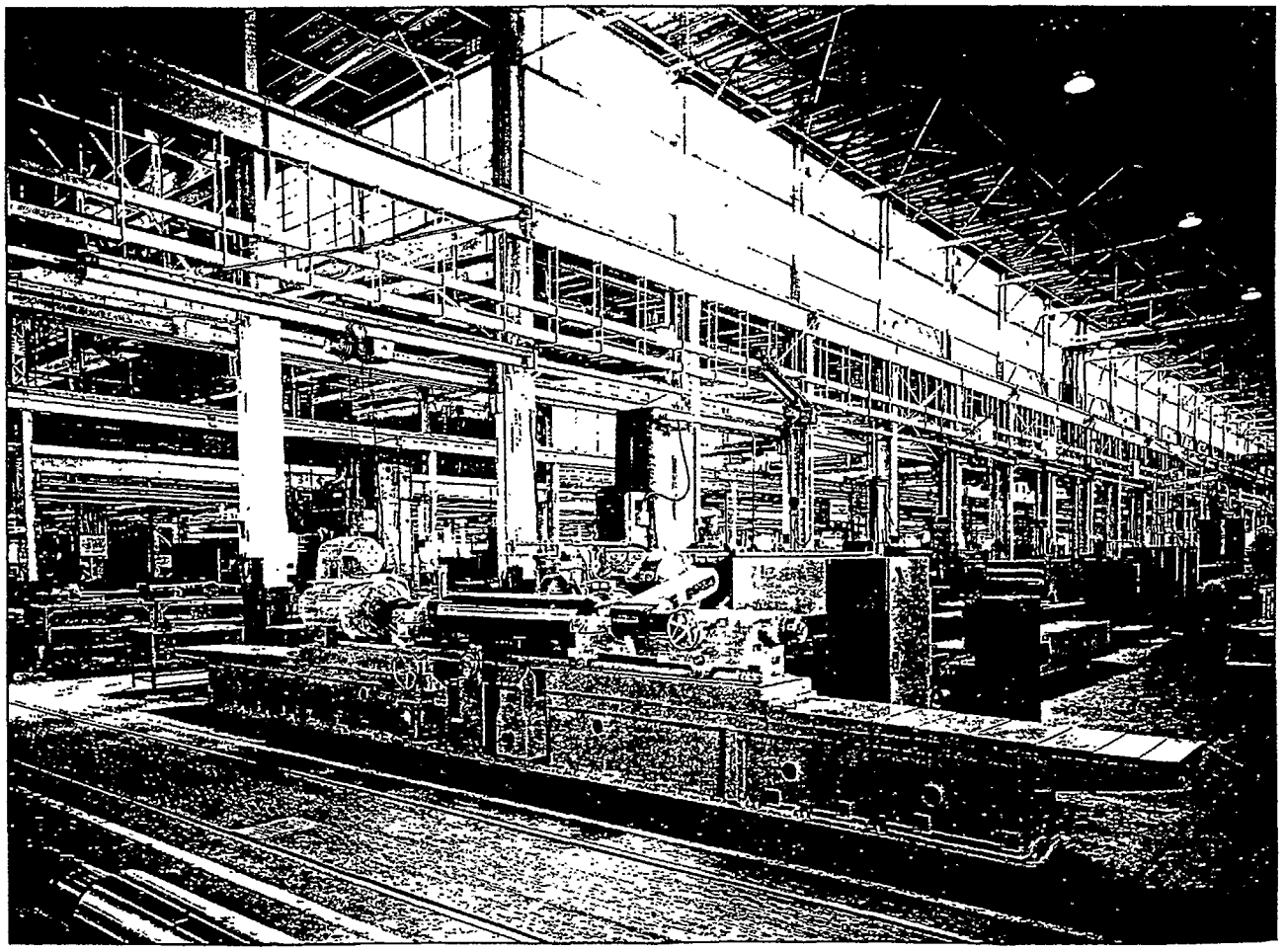
MIL 000145

Roll Grinding Applications

Application	Recommendation
Cast Iron Rolls - Regrinding	CK36-I7-B320
Cold Mill Rolls: Backup	H5AK30-J8-B320
Regrinding Tandem Rolls	
First Stand	H5AK30-J8-B320
Other Stands	AK80-I8-B320
Copper - Finishing	C150-L8-B320
Granite Rolls:	
Rough - New	C36-K8-B320
Regrinding	C54-J8-B320
Hot Mill Back-Up Rolls	
Regrinding	H5A30-J8-B320
Hot Mill Work Rolls	
Regrinding	CK36-I7-B320
Roughing New Rolls	AK30-L7-B320
Finishing New Rolls	C36-I7-B320

Miscellaneous Rolls

Application	Recommendation
Aluminum Rolls	
Roughing	CK30-I9-EC
Finishing	CK60-J9-EC
Paper Mill Rolls: Chilled Iron,	
Granite, Rubber Covered	
Roughing	CK36-M9-E
Finishing	CK60-M2-E
Combination	CK46-M10-E
Copper, Brass, Wood	
Roughing * Finishing	CK30-M9-E
Printing Rolls	
Rubber Print	CK36-L7-B320
Rubber Rolls	
Soft - Roughing	H5A20-L8-B320
Soft - Finishing	CK46-M8-B320
Hard - Rough or Finish	CK36-J8-B320



Wheel Related Problems

Problem	Cause	Remedy
Work shows discoloration	Improper wheel	Use softer wheel, or manipulate to get softer effect. (See "Wheel Grading Effect"). Prevent glazing and loading; use more coolant; prevent chatter.
Shiny appearance, slick feel	Improper wheel	Use coarser grit, softer bond; manipulate wheel to soften effect. (See "Wheel Grading Effect")
Grit marks	Wheel too coarse or too soft	Select correct wheel
	Too much difference in grit size between roughing and finishing wheels	Use finer roughing wheel or finish out better with roughing wheel
Isolated deep marks	Coarse grits or foreign matter in wheel face	Dress out.
Wide irregular marks of varying depth.	Wheel too soft	Use harder grading. (See "Wheel Grading")
Widely spaced spots on work	Oil spots or glazed areas on wheel face	Balance and true wheel; avoid getting oil on wheel face.
Chatter marks fairly long, wide, and evenly spaced at wide intervals, and generally discolored; wheel glazed or loaded	Wheel grading too hard	Select softer grade, more open bond, or coarser grit. (See "Wheel Grading")
Wavy traverse lines	Ragged wheel edges	Round off wheel edges.
Long, regularly spaced chatter marks forming checkerboard pattern	Wheel out of balance	Rebalance carefully on own mounting. Repeat after truing operation; if trouble persists, run wheel without coolant to throw off excess water; store on side to prevent water from settling at lower edge of wheel.
	Wheel out of round	True before and after balancing; true sides to face.
Deep, irregular marks	Loose wheel flanges	Tighten flanges using blotters or lead washers.
Narrow and deep regular marks	Wheel too coarse	Use finer grit.
Regularly spaced chatter marks	General vibration	Check alignment and couplings; be sure motor and spindle are in balance.
Chatter marks spaced synchronously with building vibration	Building vibration	If a heavy grinder, provide a separate foundation, independent of the surrounding floor. If a light grinder, tighten or loosen anchor belts. Vibration dampers will often help. Moving the machine to a better location is sometimes the best solution.
Regular or irregular chatter marks	Faulty thrust bearings	Replace thrust bearings.
Chatter marks, long and widely spaced, regular in pattern, but may vary around body of work.	Back lash in drive gears	Replace old gears or use belt drive; check lubricant.
Irregular chatter marks	Work centers or work not true, or improperly lubricated	Check fit of centers and rests; provide constant and even lubrication. On large jobs, such as in roll grinding, provide hold-down clamps on necks and arrange for adequate lubrication.

Belts

Belts that whip, are uneven, or have poor splices will cause vibration. Belts that slip cause losses of power, speed, and removal capabilities, not to mention poor grinding results.

Problem	Cause	Remedy
Regularly or irregularly spaced chatter marks of any width, but following one pattern	Metal belt lacing on spindle drive	Use endless belt.
Regularly but widely spaced chatter marks	Uneven belt	Plane belt to uniform thickness and width; have all sections of uniform pliability.
Uneven scratches on work	Whipping belt	Take up belt.

Spindle Bearings

A reliable high quality bearing of babbit or bronze with the right oil and heat clearance will permit high quality finishes and excellent grinding wheel efficiency. Bearings should be allowed to heat up before attempting fine finishes since the bearing will expand from the heat, causing a tighter fit to the spindle.

Problem	Cause	Remedy
Chatter marks — short, close, and evenly spaced	Loose wheel spindle	Reduce speed. Tighten or refit bearings, lap bearings to spindle. Increase quantity or improve quality of oil. Allow sufficient preliminary heating. Take up thrust bearings.

Optimizing - Roll Grinding

SPECIFICATION; H5AK36-J8-B320

Abrasive:

1. AK}	Harder acting, less aggressive, better life
2. 10AK}	Faster cut, less life, more aggressive

Grit Size:

1. 367}	Slightly softer, better finish, slower cut
2. 46}	Same as above except to more of a degree

Grade:

1. I8}	Freer cut, may break down, more aggressive
2. K8}	Slower cut, longer life, less aggressive

Bond:

1. B70}	Harder
2. B320M}	Softer, more open

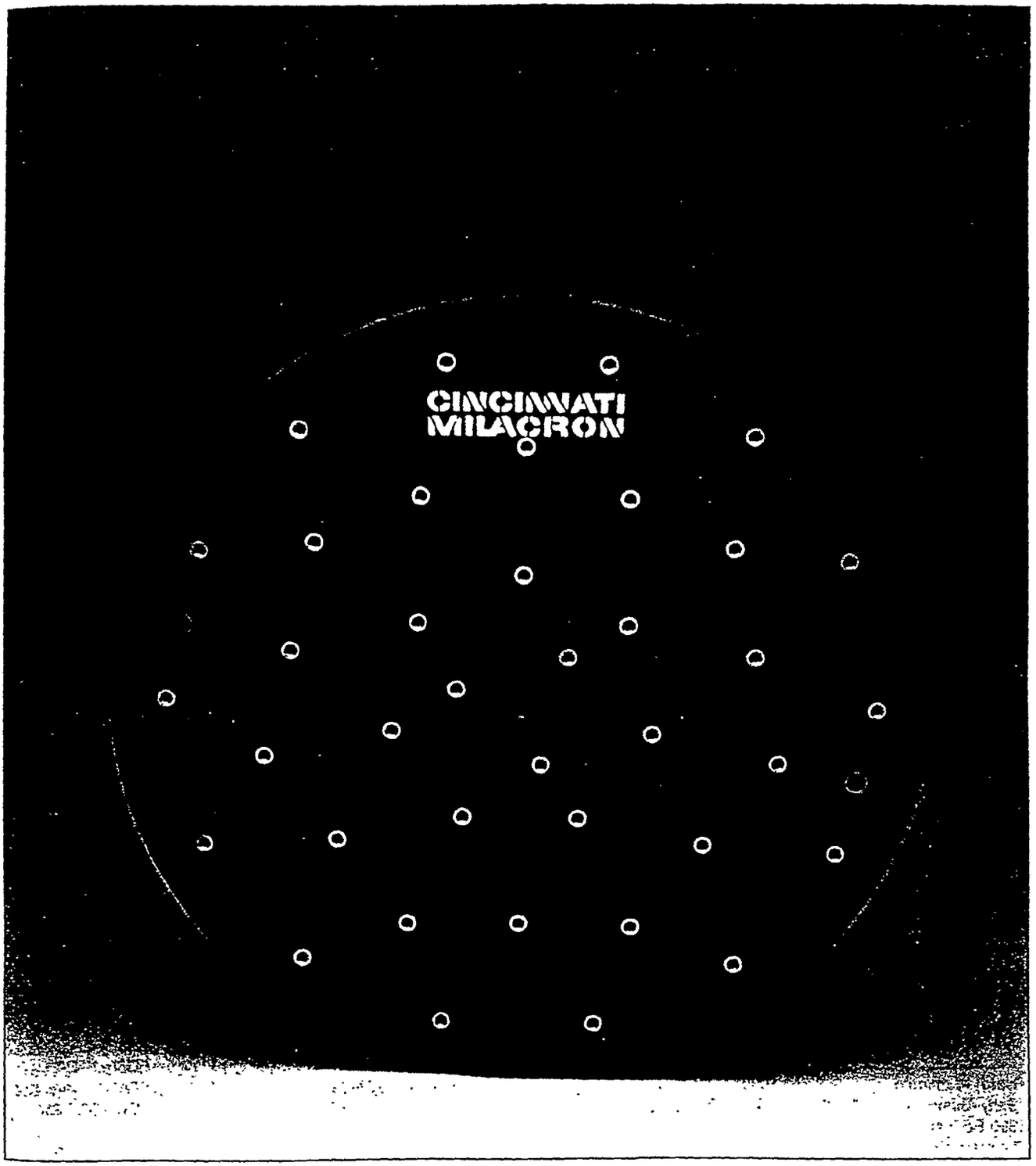
FIN-TECH
FINISHING TECHNOLOGIES

Case History

Application:	Roll Grinding
Part:	Steel Rolls 480mm dia.
Material:	Forged Steel 95 shore hardness
Stock Removal:	.1mm
Surface Finish:	.04-.07 Ra
Wheel Spec.:	320 grit size
Coolant:	Synthetic

MIL 000148

7 Disc Grinding Wheels



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Specification Selection Guide

In all types of grinding, the work area, stock removal, tolerances required and wheel speed can have a considerable effect on specification selection. This is particularly true in disc grinding. Hence, the following recommendations are general in nature. For further help, contact your Cincinnati Millacron Marketing Company Sales Representative.

Application	Wheel Specifications
Alnico-Magnets	C2A601-H9-B90
Aluminum Castings	
small-light work	6C46-I9-B90
large-heavy work	6C24-K11-B320
Asbestos clutch facings	6C24-I11-B320
Brake linings	
woven	6C24-J11-B320
moulded commercial finish	6C24-K11-B320
moulded quality finish	YC60-I11-B90
Brass and Bronze castings	
commercial finish	6C36-H11-B320
Brick	
squaring ends-soft	6C24-I11-B320
hard	6C24-J11-B320
refractory	6C24-L11-B320
Carbon	6C46-K11-B90
Cast iron castings	
small-light work	6C36-J9-B90
large-heavy work	6C24-J11-B320
Chain saw blades	97A601-J11-B90
Clutch plates	97A601-I11-B90
Connecting rods	97A601-H11-B90
Copper	6C46-H11-B90
Dies (hardened steel)	97A801-H9-B90
Fibre	6C24-I11-B320
Gears (hardened steel)	97A801-H9-B90
Golf club heads	97A461-L9-B90
Grey Iron	6C46-J11-B90
Knives	97A461-I9-B90

Application	Wheel Specifications
Malleable iron castings	97A461-K9-B90
Piston pin ends	97A601-K9-B90
Piston rings	
roughing	6C46-G9-B90
semi-finish	6C60-H9-B90
finish	6C80-I9-B90
Plumbing fixtures (vitreous)	6C46-I11-B90
Porcelain (finish)	6C100-J9-B90
Rails (surfacing)	97A461-J11-B90
Roller bearing ends	97A801-I9-B90
Roller bearing race cage surfacing	97A801-I9-B90
Springs	
heavy wire	97A241-N9-B320
medium wire	97A241-N9-B320
small wire	97A461-N9-B90
Steel - hard	
rough	97A801-G9-B90
finish	97A1001-I9-B90
Steel - soft	
rough	97A461-J9-B90
finish	97A601-K9-B90
Steel forgings	
small-light work	97A461-J9-B90
large-heavy work	97A301-H11-B90
Tile (ceramic)	6C80-K9-B90
Valve stem ends	97A601-N6-B90
Wrenches	
roughing	C2A461-K9-B90
finishing	C2A601-M9-B90

The OD-ID size relationship usually determines the number of zones to be used (see example below):

OD MINUS ID

MATERIAL	EQUAL TO GREATER THAN 24"	GREATER THAN 12" LESS THAN 24"	EQUAL TO LESS THAN 12"
Hard Steel	97A801-G/F/E9-BAM	97A801-G/F9-BAM	97A801-G9-BAM
Soft Steel	2A601-L/K/J9-B90	2A601-L/K9-B90	2A801-L9-B90
Cast Iron	6C601-J/I/H9-B90	6C60-J/I9-B90	6C60-J9-B90
(Hard) Aluminum	97A801-K/J/I9-B90	97A801-K/J9-B90	97A801-K9-B90
(Soft) Aluminum	6C60-G/F/E9-BAM	6C60-G/F9-BAM	6C60-G9-BAM
(300 Series) Stainless Steel	6C60-K/J/I9-B90	6C60-K/J9-B90	6C60-K9-B90
(400 Series) Stainless Steel	97A801-G/F/E9-BAM	97A801-G/F9-BAM	97A801-G9-BAM
Powdered Metal	C2A801-G/F/E9-BAM	C2A801-G/F9-BAM	C2A801-G9-BAM

Bolt Hole Patterns

18" Disc

18 x T x ID

IN5000 0	IN5100 4
IN5010 1/4	IN5110 5
IN5020 1/2	IN5120 6
IN5030 3/4	IN5130 7
IN5040 1	IN5140 8
IN5050 1 1/4	IN5150 9
IN5060 1 1/2	IN5160 10
IN5070 1 3/4	IN5170 11
IN5080 2	IN5180 12
IN5090 3	

ID	Outer Row	Next Row	Next Row	Next Row
>0 ≤2	10 on 14 3/4	5 on 11	5 on 8	3 on 4
-2 ≤6	10 on 14 3/4	5 on 11	5 on 8	—
>6 ≤9	10 on 14 3/4	5 on 11	—	—
>9	10 on 14 3/4	—	—	—

23" Disc

23 x T x ID

IN5190 0	IN5320 7
IN5200 1/4	IN5330 8
IN5210 1/2	IN5340 9
IN5220 3/4	IN5350 10
IN5230 1	IN5360 11
IN5240 1 1/4	IN5370 12
IN5250 1 1/2	IN5380 13
IN5260 1 3/4	IN5390 14
IN5270 2	IN5400 15
IN5280 3	IN5410 16
IN5290 4	IN5420 17
IN5300 5	IN5430 18
IN5310 6	

ID	Outer Row	Next Row	Next Row	Next Row	Next Row
≥0 ≤3	12 on 20	6 on 18	6 on 14	6 on 8	3 on 5 1/4
>3 ≤6	12 on 20	6 on 18	6 on 14	6 on 8	—
>6 ≤12	12 on 20	6 on 18	6 on 14	—	—
>12 ≤16	12 on 20	6 on 18	—	—	—
>16	12 on 20	—	—	—	—

26" Disc

26 x T x ID

IN5440 0	IN5580 8
IN5450 1/4	IN5590 9
IN5460 1/2	IN5600 10
IN5470 3/4	IN5610 11
IN5480 1	IN5620 12
IN5490 1 1/4	IN5630 13
IN5500 1 1/2	IN5640 14
IN5510 1 3/4	IN5650 15
IN5520 2	IN5660 16
IN5530 3	IN5670 17
IN5540 4	IN5680 18
IN5550 5	IN5690 19
IN5560 6	IN5700 20
IN5570 7	

ID	Outer Row	Next Row	Next Row	Next Row	Next Row
≥0 ≤2	14 on 22 1/2	7 on 16 3/4	7 on 15	7 on 8 1/2	3 on 4 1/4
>2 ≤6	14 on 22 1/2	7 on 16 3/4	7 on 15	7 on 8 1/2	—
>6 ≤13	14 on 22 1/2	7 on 16 3/4	7 on 15	—	—
14	14 on 22 1/2	7 on 16 3/4	—	—	—
>14	14 on 22 1/2	—	—	—	—

30" Disc

30 x T x ID

IN5710 0	IN5860 9
IN5720 1/4	IN5870 10
IN5730 1/2	IN5880 11
IN5740 3/4	IN5890 12
IN5750 1	IN5900 13
IN5760 1 1/4	IN5910 14
IN5770 1 1/2	IN5920 15
IN5780 1 3/4	IN5930 16
IN5790 2	IN5940 17
IN5800 3	IN5950 18
IN5810 4	IN5960 19
IN5820 5	IN5970 20
IN5830 6	IN5980 21
IN5840 7	IN5990 22
IN5850 8	

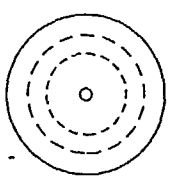
ID	Outer Row	Next Row	Next Row	Next Row	Next Row
≥0 ≤2	16 on 26 1/2	12 on 22	12 on 18	8 on 11	3 on 4 1/4
>2 ≤9	16 on 26 1/2	12 on 22	12 on 18	8 on 11	—
>9 ≤16	16 on 26 1/2	12 on 22	12 on 18	—	—
>16 ≤20	16 on 26 1/2	12 on 22	—	—	—
>20	16 on 26 1/2	—	—	—	—

Disc Wheel Specification Selection Guide

1 **Grain Type** Information needed Material to be ground	Aluminum Oxide	Silicon Carbide	AO-SC Combination	2 **Grit size** Stock Removal / Finished Required: Stock removal ≥.020 Finish required ≥ 30 RMS	> .005 SR <.020 >15 RMS <30 RMS	≤.005 SR ≤15 RMS	3 **Grade** Disc Size to determine the number of zones if OD minus ID is: Equal to less than 12"	Greater than 12" Less than 24"	Equal to greater than 24"	4 **Structure** Part Size: Contact area less than 2 sq. in	Over 2 sq. in.	5 **Bond** Always Resin: Bond Type
Hard Steel >50Rc	97A			801	801	1001	G	G/F	G/F/E	9	11	B2
Soft Steel <50Rc	2A			46	60		L	L/K	L/K/J	9	11	B2
Cast Iron		6C		46	60	120	J	J/I	J/I/H	9	11	B2
Aluminum (Hard)	97A			601	801	1201	K	K/J	K/J/I	9	11	B2
Aluminum (Soft)		6C		46	60		H	H/G	H/G/I	9	11	B2
Stainless Steel 300 Series		6C		46	60		K	K/J	K/J/I	9	11	B2
Stainless Steel 400 Series	97A			801	801	1201	G	G/F	G/F/E	9	11	B2
Alnico			C2A	801	801	1201	J	J/I	J/I/H	9	11	B2
Powered Metal			C2A	80	80	1201	G	G/F	G/F/E	9	11	B2
Nonmetallics		6C		80	80	120	G	G/F	G/F/E	9	11	B2

Zone Wheels —
Varying hardness across the grinding zone

Purpose —
To maintain disc flatness due to changes in the rate of stock removal and surface speed across the grinding zone



Selection by numbers
Refer to example below

Example **Valve Plate**	1 Material	2 Stock Removal	Finish Required	3 Disc Size	4 Part Size	5 Bond
	Cast Iron	.020	32 RMS	30 x 2 x 1 3 zone	Approx. 4 x 5 x 3/4"	
	6C	46		J/I/H	11	B90
	Roughing Finishing C9A	1201		I	11	B90

6

Coolant Slots

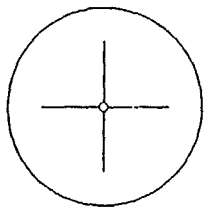
Type of Workfeed

Slots are used on most thrufeed applications

Purpose—
Coolant distribution

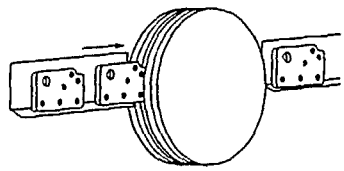
Description—
- standard pattern—4 radial slots
- ⅛" or ¼" wide (use ⅛" wide for parts that are less than ½" dia.)
- specify diameter on order (usually 2/3 of the disc diameter; i.e. ¼" slots to a 20" diameter on 30" wheel)

(See the sample order below.)

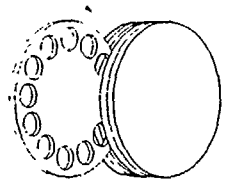


Coolant Slots Yes____ No____

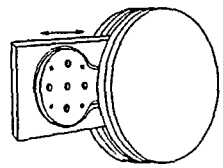
Basic Feed Methods



Thrufeed—
Highest production rates possible in double disc grinding. A continuous line of parts are fed through the machine



Rotary Carrier—
High production for small and medium sized parts and parts with irregular shapes.



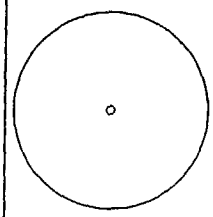
Oscillating and Reciprocating—
Generally used for short production runs, heavy stock removal, large workpieces, and when good accuracy is required

7

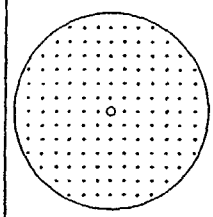
Perforations/Smooth Face

Finish Required and Part Size

Use smooth face disc when
- required finish is less than 15 RMS
- parts are less than ½" in diameter
- otherwise use perforated face



Smooth face
Purpose—
Used when grinding small diameter parts. Produces fine finish



Perforated face
Purpose—
Aids in swarf removal and grain penetration (free cutting)

Perforations____ Smooth Face____

7

6
Type of Workfeed
Thrufeed

Coolant Slots Yes● No____

7
Finish Required
and Part Size

Perforations● Smooth Face____

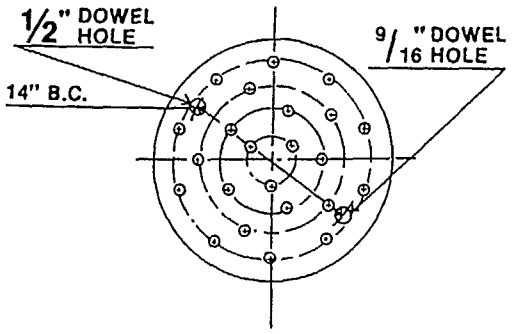
Recommended
Specifications

6C46—J/I/H 11-B2
4 - ¼" slots to a 20" dia.
Perforated

Machine and Wheel Sizes

18" Disc

18 x T x ID	
IN5000	0
IN5010	1/4
IN5020	1/2
IN5030	3/4
IN5040	1
IN5050	1 1/4
IN5060	1 1/2
IN5070	1 3/4
IN5080	2
IN5090	3
IN5100	4
IN5101	4 1/2
IN5102	4 3/4
IN5110	5
IN5120	6
IN5130	7
IN5140	8
IN5150	9
IN5157	9 3/4
IN5160	10
IN5170	11
IN5180	12



Dowel holes - Dowel holes will be supplied as shown on sketch unless otherwise specified.

Slots - Standard pattern is 4 radial slots, 1/8" or 1/4" wide, to a specified diameter.

Perforations - Only one pattern is available. Perforations are 3/8" in diameter on 1 1/4" centers.

Max. wheel thickness - 3" useable abrasive.

Typical wheel description as it should appear on an order:

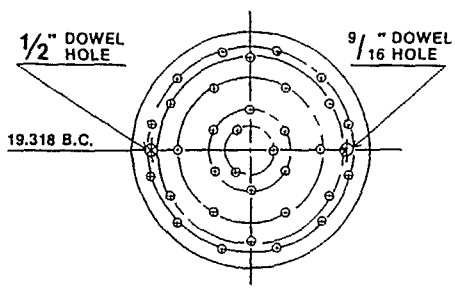
Print #IN5040, 18 x 1 x 1 — 97A801-H/G/F9-B90
4 - 1/4" slots to a 12" dia.
"Perforated"

Bolt Hole Patterns

ID	Outer Row	Next Row	Next Row	Next Row
>0≤2	10 on 14 3/4	5 on 11	5 on 8	3 on 4
>2≤6	10 on 14 3/4	5 on 11	5 on 8	—
>6≤9	10 on 14 3/4	5 on 11	—	—
>9	10 on 14 3/4	—	—	—
	10 on 14 3/4			

23" Disc

23 x T x ID	
IN5190	0
IN5200	1/4
IN5210	1/2
IN5220	3/4
IN5230	1
IN5240	1 1/4
IN5250	1 1/2
IN5260	1 3/4
IN5270	2
IN5280	3
IN5290	4
IN5300	5
IN5310	6
IN5320	7
IN5330	8
IN5340	9
IN5350	10
IN5355	10 1/2
IN5360	11
IN5370	12
IN5380	13
IN5390	14
IN5400	15
IN5410	16
IN5420	17
IN5427	17 3/4
IN5430	18



Dowel holes - Dowel holes will be supplied as shown on sketch unless otherwise specified.

Slots - Standard pattern is 4 radial slots, 1/8" or 1/4" wide, to a specified diameter.

Perforations - Only one pattern is available. Perforations are 3/8" in diameter on 1 1/4" centers.

Max. wheel thickness - 3" useable abrasive.

Typical wheel description as it should appear on an order:

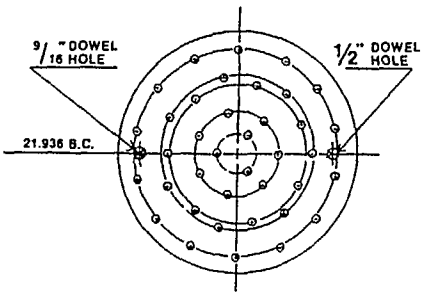
Print #IN5230, 23 x 2 x 1 — 97A801-H/G/F9-B90
4 - 1/4" slots to a 14" dia.
"Perforated"

Bolt Hole Patterns

ID	Outer Row	Next Row	Next Row	Next Row	Next Row
≥0≤3	12 on 20	6 on 18	6 on 14	6 on 8	3 on 5 1/4
>3≤6	12 on 20	6 on 18	6 on 14	6 on 8	—
>6≤12	12 on 20	6 on 18	6 on 14	—	—
>12≤16	12 on 20	6 on 18	—	—	—
>16	12 on 20	—	—	—	—

26" Disc

26 x T x ID	
IN5440	0
IN5450	1/4
IN5460	1/2
IN5470	3/4
IN5480	1
IN5490	1 1/4
IN5500	1 1/2
IN5510	1 3/4
IN5520	2
IN5530	3
IN5540	4
IN5550	5
IN5560	6
IN5570	7
IN5580	8
IN5581	8 1/2
IN5590	9
IN5600	10
IN5610	11
IN5620	12
IN5630	13
IN5640	14
IN5650	15
IN5660	16
IN5670	17
IN5680	18
IN5690	19
IN5700	20



Dowel holes - Dowel holes will be supplied as shown on sketch unless otherwise specified.

Slots - Standard pattern is 4 radial slots, 1/8" or 1/4" wide, to a specified diameter.

Perforations - Only one pattern is available. Perforations are 3/8" in diameter on 1 1/4" centers.

Max. wheel thickness - 3" useable abrasive.

Typical wheel description as it should appear on an order:

Print #IN5480, 25 x 2 x 1 — 97A801-H/G/F9-B90
4 - 1/4" slots to an 18" dia.
"Perforated"

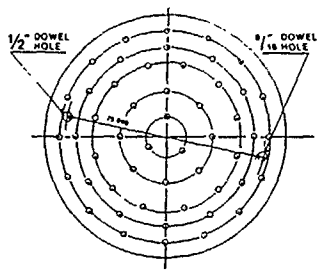
7

Bolt Hole Patterns

ID	Outer Row	Next Row	Next Row	Next Row	Next Row
≥0≤2	14 on 22 1/2	7 on 16 3/4	7 on 15	7 on 8 1/2	3 on 4 1/4
>2≤6	14 on 22 1/2	7 on 16 3/4	7 on 15	7 on 8 1/2	—
>6≤13	14 on 22 1/2	7 on 16 3/4	7 on 15	—	—
14	14 on 22 1/20	7 on 16 3/4	—	—	—
>14	14 on 22 1/2	—	—	—	—

30" Disc

23 x T x ID	
IN5710	0
IN5720	1/4
IN5730	1/2
IN5740	3/4
IN5750	1
IN5760	1 1/4
IN5770	1 1/2
IN5780	1 3/4
IN5790	2
IN5800	3
IN5810	4
IN5820	5
IN5830	6
IN5840	7
IN5850	8
IN5860	9
IN5865	9 1/2
IN5870	10
IN5880	11
IN5890	12
IN5900	13
IN5910	14
IN5920	15
IN5930	16
IN5940	17
IN5950	18
IN5951	18 3/4
IN5960	19
IN5970	20
IN5980	21
IN5990	22



Dowel holes - Dowel holes will be supplied as shown on sketch unless otherwise specified.

Slots - Standard pattern is 4 radial slots, 1/8" or 1/4" wide, to a specified diameter.

Perforations - Only one pattern is available. Perforations are 3/8" in diameter on 1 1/4" centers.

Max. wheel thickness - 3" useable abrasive.

Typical wheel description as it should appear on an order:

Print #IN5750, 30 x 2 x 1 — 97A801-H/G/F9-B90
4 - 1/4" slots to a 20" dia.
"Perforated"

Bolt Hole Patterns

ID	Outer Row	Next Row	Next Row	Next Row	Next Row
≥0≤2	16 on 26 1/2	12 on 22	12 on 18	8 on 11	3 on 4 1/4
>3≤9	16 on 26 1/2	12 on 22	12 on 18	8 on 11	—
>9≤16	16 on 26 1/2	12 on 22	12 on 18	—	—
>16≤20	16 on 26 1/2	12 on 22	—	—	—
>20	16 on 26 1/2	—	—	—	—

MIL 000155

Resinoid Disc Wheels
Application and Selection

Disc grinders are high production machines, used to grind flat and parallel parts. The machines can be horizontal or vertical spindle, single or double disc. The abrasive discs that are used on these machines are manufactured with a pattern of nut inserts molded into the back of the disc. These inserts are used to mount the abrasive disc to the steel machine plate. (The nut inset pattern must exactly match the hole pattern of the steel machine plate.)

Most common machines used:

Gardner
Besly
Mattison

Basic feed methods:

1. Thrufeed
2. Rotary
3. Oscillating
4. Reciprocating (gun type)

List of commonly ground parts:

Alnico magnets
Bearing parts
Castings (various materials)
Chainsaw blades
Clutch plates
Dies
Gears
Hand tools
Insulating brick
Knives
Piston rings
Plumbing fixtures
Springs
Valve plates
Washers
and many others
See the selection guide for illustrations and information.

Plate Mounted, NID

Application	Recommendation
Alloy Steel	R5A207-I7-BAM
Alnico:	
Roughing	A301-K6-BA
Finishing	E5A80-I7-B320
Grey Iron	R5A24-M5-BC
Malleable Iron	R5A207-N5-BC
Spring Steel	A24-M5-BC

Availability

The abrasive discs are available in a variety of compositions and styles that when properly selected and combined will provide optimum grinding performance.

Abrasive	Type	Grit Size	Grain Combination	Grade st.	Grade med.	Grade hd.	Structure dense	Structure open	Bond Resin
		coarse							
Alum. Oxide		24	nominal						
	2A	30	1	D	J	O	9	11	B90
	4A			E	K	P			
		medium							
	12A	36		F	L	Q			
	9A	46		G	M	R			
	97A	54		H	N				
	29A	60		I					
Silicon Carbide	6C	70							
	7C	80							
		fine							
Combination Alum. Oxide	CA								
	C2A	90							
	C4A	100							
	C12A	120							
	C9A	150							
		180							
		220							

Availability

— MAX THICKNESS - 3" useable abrasive
— hardback - 5/8" thick (not used in describing wheel thickness)
— inserts - 3/8" - 16 unless otherwise specified
— dowel holes - will be furnished as shown on the sketches on page unless otherwise specified.

Availability

1. Smooth face
2. Perforated face - see the selection guide for illustrations and information.
3. Slotted - 4 radial slots equally spaced - 1/8" or 1/4" wide to a specified diameter.
4. Zoned wheels or variable density

MIL 000156

Availability And Ordering

A. Availability

1.	Grain Type	- 2A, 4A, 9A, 12A, 97A, 29A,CA, C2A, C4A, C9A, C12A, 6C
2.	Grit Size	- 24 thru 220
3.	Grade (hardness)	- D thru R
4.	Structure	- 9 and 11 are standard
5.	Bond Type	- B90, B320 only
6.	Max. Useable Thickness	- 3"
7.	Hardback	- All 5/8" thick and not used in describing wheel thickness (useable abrasive only in describing thickness).
8.	Inserts	3/8" - 16 unless otherwise specified

C. Perforations

1. Available in 30", 26", 23", and 18" OD wheels.
2. Hole pattern is not variable and the hole diameter is fixed at 3/8".
3. "Perforated" must be specified on the order with the general wheel description. Perforations will not appear on any prints.
4. A wheel can be both slotted and perforated. Data as it would appear on a typical order for a slotted wheel with a perforated face:
   30 x 2 x 1 4-1/4" slots to a 20 dia. "Perforated"

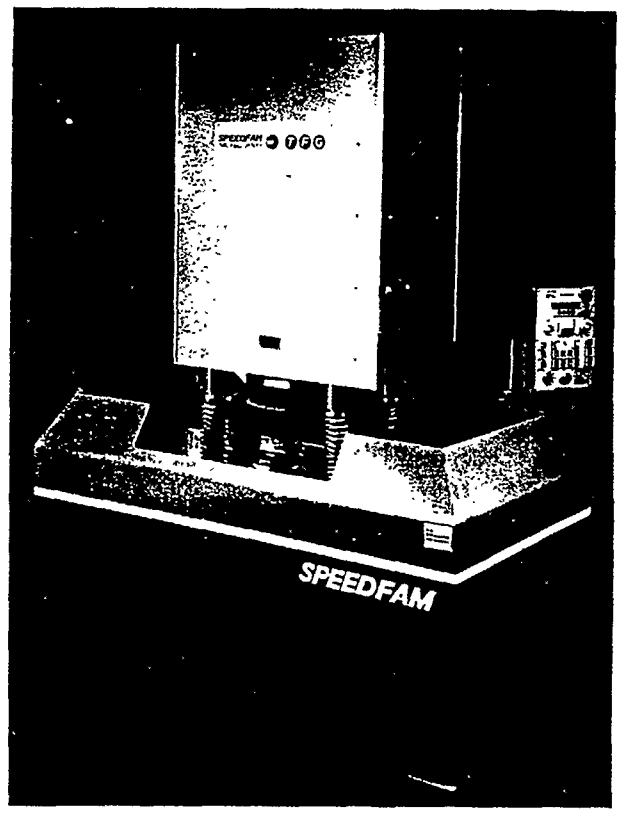
D. Zoned Wheels

1. Disc wheel can be graded in the following ways:
   a. Single grade - EXAMPLE: 97A801-L9-B90 (B320)
   b. Two zone - EXAMPLE: 97A801-K/J9-B90 (B320)
   c. Three zone - EXAMPLE: 97A801-L/K/J9-B90 (B320)
2. Grit type or size cannot vary between zones:
   EXAMPLE: 60 grit inner zone
   80 grit outer zone
3. Letter grades cannot vary more than one grade between zones:
   INCORRECT EXAMPLE: 97A801-K/I/9-B90 (B320)
   CORRECT EXAMPLE: 97A801-K/J/9-B90 (B320)
4. Grade breaks in zone wheels are fixed.
   Note: Some disc wheel manufacturers show the grade break along with the wheel size.
   EXAMPLE: 30 x 2 x 19* x 1
   Grade break (Not used in any Cincinnati Milacron wheel description)
   *19" would be the diameter where the grade breaks
5. In most cases a suffix such as this follows the bond symbol. Below is the explanation.

B. Slots

1.	Number:	4 radial slots from ID-Std.
	Width:	1/8" - 1/4" available
	Length:	to be specified on order
	Depth:	fixed to hardback

2. Description of slots must appear on the order with the general wheel description.
   EXAMPLE: 4 - 1/4" radial slots to 20 dia.
   Slots will not appear on any prints.



Single Disc Grinder
Typical Wheel Size 18 x 3 x —
Nut Inserted Disc Wheel
Typical Wheel Grade — C2A601-P9-B90

Necessary Ordering Information

		EXAMPLE
1.	Print number	IN5750
2.	Disc dimensions OD x thickness x ID)	30 x 2 x 1 -
3.	Disc specification	97A801-G/F/E/11-B90 (B320)
4.	Slots (if needed)	4-1/4" slots to a 20" dia.
5.	State "Perforated" (if needed)	Perforated

MIL 000157

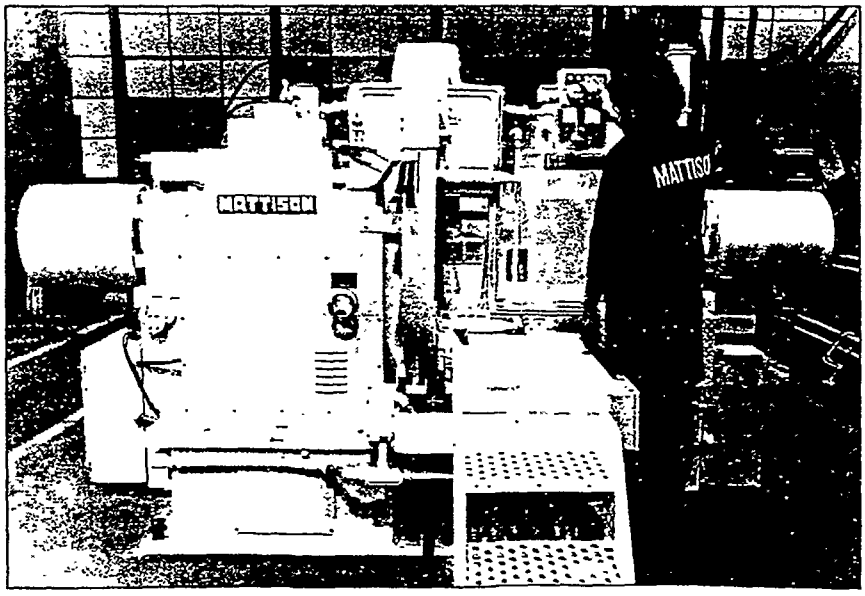
Background

Disc wheels are used on disc grinders to grind flat surfaces. These wheels are resinoid bonded and usually used in sets of two. They are not mounted like most standard wheels. There is a series of nut inserts in the "back" of the wheel. Bolts are placed through a plate and screwed into the nut inserts in the wheels.

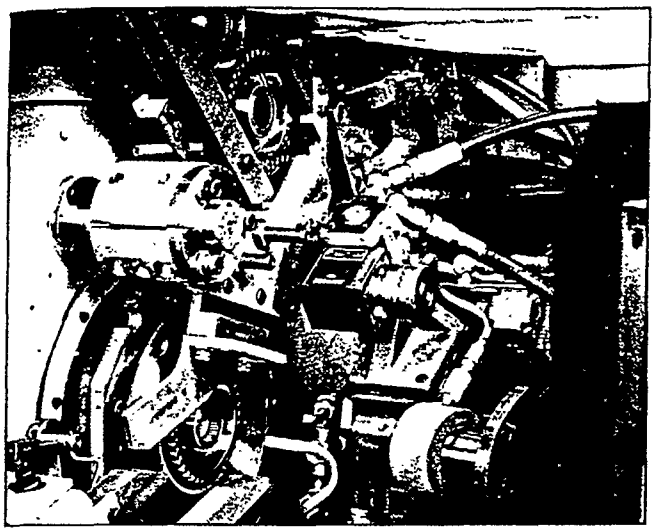
There are single disc grinders (1 wheel set-up), double disc (2 wheel set-up), and triple disc grinders (3 wheel set-up, 1 roughing wheel and 2 finishing wheels). Disc grinders are normally high production grinders. In many applications, one disc grinder will feed a large number of other grinders or assembly operations. Disc grinders use a large number of wheels per machine because of the high production nature and softer wheel grades used for this operation.

Trouble Shooting

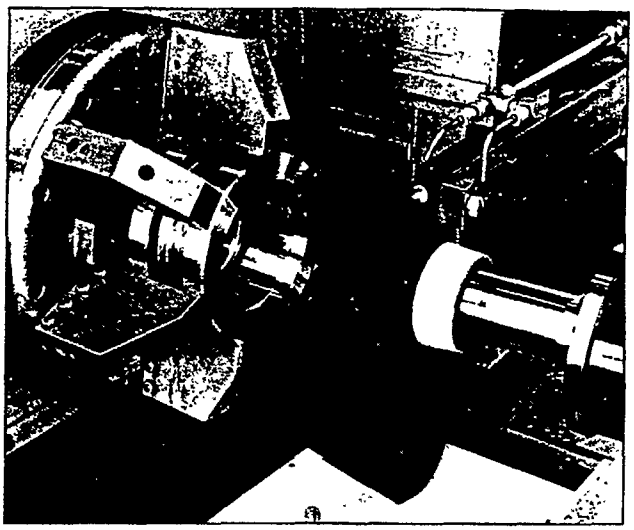
Problem	Corrective Action
burning parts	• Use softer abrasive spec • Speed up dresser traverse • If using a diamond dressing tool check its condition • Consider different type of dressing tool (e.g., star cutter) • Increase coolant capacity • Reduce disc speed if possible • Increase feed rate • Use perforated disc
scratches	• Use finer abrasive spec • Use smooth face disc • Clean coolant tanks and check filters • Add finish pass
scratches (cont.)	• Slow down dresser traverse • Consider different type of dressing tool (e.g., diamond cluster) • Vary feed rate
sizing	• Disc may be too hard or soft; adjust abrasive spec accordingly • Increase coolant capacity • Reduce feed rate • Speed up dresser traverse • Consider different type of dressing tool (e.g. star cutter)



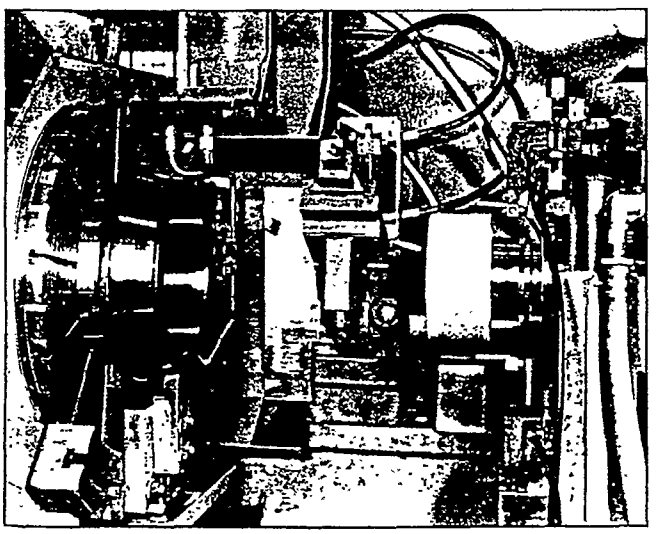
8 Internal Grinding Wheels



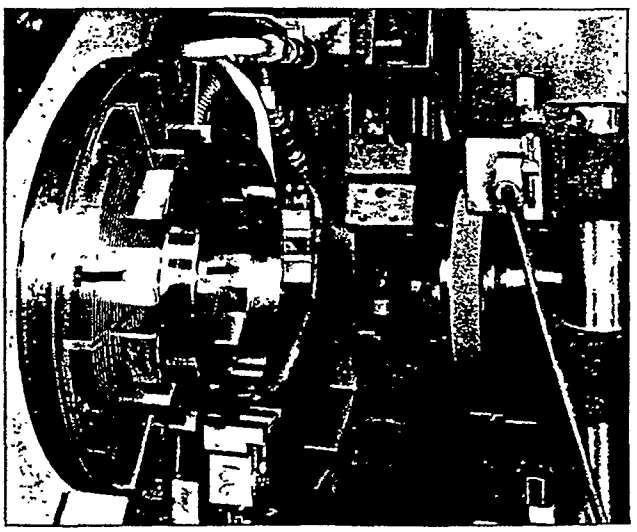
Machine — 1EF70 Internal Grinding Machine
Material — Rockwell "C" 58-62
Operation — Finish grind recessed hub OD
Grinding wheel — 12A-80-J6-VFME
29A801-J6-VFME
3MSB801-I6-VSAE



Machine — 2EF CINTERNAL Multisurface CNC Grinding Machine
Material — Rockwell "C" 60-62
Operations — Plunge grind inner ID, face plunge inner face, recip. center bore, vector plunge lip and ID, recip. face.
Grinding Wheel — 12A-80-J6-VFME
29A801-J6-VFME
3MSB801-I6-VSAE



Machine — 2EF90 Internal Grinding Machine
Material — Rockwell "R" 60-64
Operation — Finish grind bore
Grinding wheel — 4A-60-J4-VFM
9A60-J4-VFM
3MSB601-I4-VSAE



Machine — 273A Universal Internal Grinding Machine
Material — Rockwell "C" 56-62
Operations — Finish grind roller path
Grinding Wheel — 2A-60-K6-VFM
9A601-K6-VFM
3MSB601-I8-VSAE

Starting Grade Recommendations

Wheel Grades For Internal Grinders			
Material	**Type 1 and 5**	**Mounted Wheel**	**Diamond Wheel**
Alnico	12A60-J6-VFM	9A60-N-V6	
Aluminum	6C46-K6-VSC	6C60-K-V7	
Aluminum Alloys	2A60-H6-VFM	9A60-K-V6	
Ball and Roller Bearings	97A801-K6-VFM		
Bearing Races (Form Gr.)	3MSB801-J6-VSA	9A60-L-V6	
Brass	6C46-J6-VSC	6C60-L-V7	
Bronze (Soft)	6C46-J6-VSC	6C60-L-V7	
Bronze (Hard)	97A601-K6-VFM	6C60-L-V7	
Cast Iron	97A461-J6-VFM	2A60- N-V6	
Bushings (Cast Iron)	12A60-H6-VFM	2A60-K-V6	
Bushings (Steel - Hard)	3MSB601-I4-VSA	9A60-L-V6	
Carbide (Ring Gages, Etc.)	3MSB601-J6-VSAE	5C80-L-V7	MD120-N100-B 1/8
	5C120-J6-VSC	5C120-K-V7	MD220-N100-B 1/8
Cemented Carbide (Dies, Etc.)			
Roughing	5C60-K6-VSC	5C80-L-V7	MD120-N100-B 1/8
Finishing	5C120-J6-VSC	5C120-K-V7	MD220-N100-B 1/8
Chromium Plated Parts			
(Small)	12A80-K4-VFM	9A60-L-V6	
(Large)	12A80-J4-VFM	9A60-K-V6	
Connecting Rods	97A601-L6-VRW	9A60-N-VFM	
Glass	6C80-J6-VSC	6C80-K-V7	
Dies - Blanking & Drawing			
Carbon Steel	12A60-J6-VFM	9A80-L-V6	
High Carbon - High Chrome	12A80-J6-VFM	9A80-K-V6	
Meehanite	12A46-J4-VFM	2A60-K-V6	
Motor Stators			
Laminated Silicon Steel	2A60-L4-VFM	2A60-M-V6	
Steel (Casting)	2A60-L4-VFM	2A60-M-V6	
Miscellaneous Forgings	12A60-L4-VFM	2A60-M-V6	
Gears			
Soft	2A60-L6-VFM	2A60-N-V6	
Hardened	3MSB601-J6-VSA	9A60-L-V6	
High Speed Steel			
Hardened	9A801-J6-VRW	9A601-K-V6	
Green Grind	2A60-L4-VFM	9A60-M-V6	
Monel Metal	6C60-J6-VSC	6C60-L-V7	
Molybdenum			
Cylinders (Aircraft)			
Roughing	12A46-J4-VFM		
Finishing	9A60-I4-VFM		
Regrinding	12A46-J4-VFM		
Nitrided Steel			
Cylinders (Aircraft)	12A46-I6-VFM		
Before Nitriding	97A461-J4-VFM		
After Nitriding	6C60-J6-VSC		
Regrinding	6C60-J6-VSC		
Rocker Arm	2A60-L6-VFM		
Sprayed Metal	6C60-J6-VSC		
Steel - General Purpose			
Castings & Forgings	2A601-K6-VFM	2A60-N-V6	
Soft	97A461-M4-VFM	2A46-N-V5	
Hardened	9A60-K6-VFM	9A60-L-V6	
Nitrided	12A80-K4-VFM	12A80-L-V6	
Stainless Steel			
300 Series	6C60-K6-VSC	6C60-L-V7	
400 Series	97A601-J4-VFM	9A60-K-V6	
Titanium	6C60-L6-VSC	6C80-M-V7	
Universal Joint Cups	3MSB1001-K4-VSA	2A80-M-V6	
Valve Seats			
Cast Iron	6C46-I6-VSC		
Inside Diameter	9A60-N4-VFM		
Stellite Seats	9A60-04-VFM		
Valve Lifter Bodies	12A80-L6-VFM		

To substitute VRW for VFM, go 1 grade softer.

Wheel Size & Speed Specification Selection Guide

Wheel size recommendations. Wheels should be ordered as close to "ready grind" size as possible. Some allowance for truing the wheel must be made. For production internal grinding operations, wheel can be ordered with decimal sizes to minimize oversize and decrease the amount of truing.

	Wheel Diameter		Wheel Width	
Hole diameter to be ground	Ordered	Trued before using	Average	Standard range
1/8	1/8	7/64	3/16	1/8 - 3/16
3/16	3/16	11/64	1/4	5/16 - 1/4
1/4	1/4	7/32	5/16	1/4 - 5/16
5/16	5/16	9/32	3/8	5/16 - 3/8
3/8	3/8	11/32	7/16	5/16 - 7/16
7/16	7/16	13/32	1/2	3/8 - 1/2
1/2	1/2	7/16	1/2	3/8 - 1/2
9/16	1/2	1/2	1/2	1/2 - 5/8
5/8	5/8	17/32	5/8	1/2 - 5/8
11/64	11/16	19/32	5/8	1/2 - 5/8
3/4	3/4	21/32	3/4	5/8 - 1
13/16	3/4	23/32	3/4	5/8 - 1
7/8	7/8	3/4	7/8	3/4 - 1
15/16	7/8	13/16	7/8	3/4 - 1
1	15/16	7/8	1	3/4 - 1
1-1/8	1	31/32	1-1/8	3/4 - 1-1/4
1-1/4	1	1	1-1/4	1 - 1-1/4
1-3/8	1-1/8	1-1/8	1-1/4	1 - 1-1/4
1-1/2	1-1/4	1-1/4	1-3/8	1 - 1-1/2
1-5/8	1-3/8	1-3/8	1-1/2	1 - 1-1/2
1-3/4	1-3/8	1-5/16	1-1/2	1 - 1-1/2
1-7/8	1-3/8	1-3/8	1-1/2	1 - 1-1/2
2	1-1/2	1-1/2	1-1/2	1 - 1-1/2
2-1/4	1-3/4	1-11/16	1-1/2	1 - 1-1/2
2-1/2	2	1-7/8	1-1/2	1 - 1-1/2
2-3/4	2	2	1-1/2	1 - 1-1/2
3	2-1/4	2-1/4	1-1/2	1 - 1-1/2
3-1/4	2-1/2	2-7/16	1-1/4	3/4 - 1-1/2
3-1/2	2-1/2	2-1/2	1-1/4	3/4 - 1-1/2
3-3/4	3	2-13/16	1-1/4	3/4 - 1-1/2
4	3	3	1-1/4	3/4 - 1-1/2
4-1/2	3-3/8	3-3/8	1-1/4	3/4 - 1-1/2
5	4	3-3/4	1	3/4 - 1-1/2
5-1/2	4	4	1	3/4 - 1-1/2
6	4-1/2	4-1/2	1	3/4 - 1-1/2
6-1/2	5	4-7/8	1	3/4 - 2
7	5-1/4	5-1/4	1	3/4 - 2
7-1/2	5-3/4	5-5/8	1	1 - 2
8	6	6	1	1 - 2
8-1/2	6-1/2	6-3/8	1-1/2	1 - 2
9	6-1/2	6-1/2	1-1/2	1 - 2
9-1/2	7	7	1-1/2	1 - 2
10	7	7	1-1/2	1 - 2

Wheel Speeds

Due to the size of the hole ground and the necessarily small size of the grinding wheel, it is advisable to use as large a wheel as possible that will enter the hole and still allow coolant to enter the grinding zone to cool the part and benefit the grinding operation. The chart at the right indicates the maximum recommended wheel diameter for a given hole size.

Diam. Of Wheel in Inches	Mm. (Approx)	Peripheral Speed in Feet per Minute and Meters per Second									
		4000 Ft. 20.3M	4500 Ft. 22.9M	5000 Ft. 25.4M	5500 Ft. 27.9M	6000 Ft. 30.5M	6500 Ft. 33.0M	7000 Ft. 35.6M	7500 Ft. 38.1M	8000 Ft. 40.6M	8500 Ft. 43.2M
		Revolutions per Minute									
1/8	3	122,230	137,510	152,790	168,060	183,350	198,624	213,903	229,182	244,461	259,740
1/4	6	61,116	68,756	76,392	84,032	91,672	99,312	106,951	114,541	122,230	129,870
3/8	9	40,744	46,594	50,928	56,021	61,115	66,208	71,301	76,394	81,487	86,580
1/2	13	30,558	34,378	38,196	42,016	45,836	46,656	53,475	57,295	61,115	64,935
5/8	16	24,446	27,502	30,557	33,615	36,669	39,724	42,780	45,836	48,892	51,948
3/4	19	20,372	22,918	25,464	28,011	30,557	33,104	35,650	38,147	40,743	43,290
7/8	22	17,462	19,645	21,826	24,009	26,192	28,374	30,557	32,740	34,923	37,105
1	25	15,279	17,189	19,098	21,008	22,918	24,828	26,737	28,647	30,557	32,467
1 1/4	31	12,275	13,750	15,300	16,800	18,350	19,862	21,390	22,918	24,446	25,974
1 1/2	37	10,185	11,460	12,730	14,005	15,280	16,552	17,825	19,098	20,371	21,645
13/4	44	8,725	9,820	10,920	12,000	13,100	14,187	15,278	16,370	17,461	18,552
2	50	7,639	8,594	9,549	10,504	11,459	12,414	13,368	14,323	15,278	16,233
2 1/4	57	6,790	7,640	8,490	9,340	10,190	11,034	11,883	12,732	13,581	14,430
2 1/2	63	6,110	6,875	7,640	8,405	9,165	9,931	10,695	11,459	12,223	12,987
2 3/4	69	5,560	6,250	6,940	7,640	8,340	9,028	9,722	10,417	11,111	11,806
3	75	5,093	5,729	6,366	7,003	7,639	8,276	8,912	9,549	10,185	10,822
3 1/2	88	4,360	4,910	5,460	6,000	6,550	7,093	7,634	8,185	8,730	9,276
4	100	3,820	4,297	4,775	5,252	5,729	6,207	6,684	7,161	7,639	8,116
5	125	3,056	3,438	3,820	4,202	4,584	4,965	5,347	5,729	6,111	6,493
6	150	2,546	2,865	3,183	3,501	3,820	4,138	4,456	4,774	5,092	5,411

A. Types of Parts

Bearing races, bushings, inserts, valve lifters, etc.

B. Selection and Application of Wheels

1. Plunge Grinding - Usually on ball groove or similar parts. Usually hard. Use finer grain 60-80 because roughing and finishing are often done on same cycle. Finish is obtained by spark out and frequency of dress. 97A801-L6-VFM would be a good general purpose grade.
2. Oscillating Grind - Usually used on bushings, inserts, lifter bodies, and other parts with straight bores. Parts can be done individually or grouped. In both cases it is a good idea to start with a wheel near the size of the bore for two reasons: to establish a good line contact and to minimize wheel change time. A good general purpose wheel grading would be 29A601-M6-VFM or 3MSB801-L6-VSA or 29A801-M6-VFM.
3. For larger diameter work, use softer grades and more open structure (6).
4. For smaller diameter work, use harder grades and closer structure (4).
5. For small hard parts where down time for wheel change is critical, CBN should be investigated.

C. Trouble Shooting

1. Coolant is very important in guarding against heat. Part should be flooded inside, and on sensitive parts an extra nozzle flowing on outside of part is helpful.
2. Due to line of contact, very good RMS values can be generated with medium grit sizes, simply by slowing down oscillation or increasing spark out.
3. Chatter - Usually the result of a hard wheel, weak quill, or possibly the wheel has worked loose.
4. Rules of thumb - Use friable grain 9A, 12A, 97A, 29A, WA, JA. Try to control stock to a minimum. Use good wetting coolant; lubrication is not as important as wettability and volume.

Internal Grinding

Internal grinding is a method whereby the inside diameter of a hole is enlarged with a grinding wheel to an accurate size and desired finish. The work is usually mounted in a chuck or fixture which fits on the work head spindle so it can be rotated while grinding the I.D. The wheel head or spindle is mounted on a cross slide to give the wheel adjustment to grind the diameter of the work. The wheel head assembly is mounted on a reciprocating table that will traverse the wheel thru the bore while grinding. It is common for holes to be ground to a tolerance of plus or minus .0001 and under special conditions, tolerances of .000025 of an inch, with finishes that seldom require lapping.

Hole sizes range from approximately 1/16 inch diameter to the maximum capacity of the machines available. When the work becomes too large and awkward to rotate, the holes can be ground with a planetary type grinder. In this type of machine, the spindle and the wheel revolve about their own axis and also revolve about the axis of the hole in the work. The work is mounted on the table and the table traverses toward the wheel.

There are three standard styles of wheel heads for most grinders, a wheel head with a solid projection spindle, a wheel head with a removable quill type of spindle, and a sleeve or enclosed type of spindle.

On miscellaneous work, toolroom and small lots, the quill type wheel head is generally used because several size quills can be used in the same head.

The proper quill is the shortest and most rigid one available that will work satisfactorily in the hole to be ground. If too large a quill is used, it will prevent the wheel from being worn down to a small stub and will block the flow of coolant, allowing the work to become too hot.

Long quills must be larger in diameter for a given hole than short stubby quills, to help prevent deflection and vibration. If it is necessary to use a long, thin quill, the selection of the correct grade becomes more critical. The wheel must be soft enough to cut freely with the light pressure that can be applied without springing the quill and still hard enough to remove stock without too much breakdown.

The sleeve or enclosed style spindles are recommended for use when grinding holes 2½" diameter or larger.

The work speed is generally 150 to 200 SFPM for most classes of work. The work speed can be used to vary the grinding action of the wheel. If the wheel acts hard, increasing the work speed will help the wheel to break down faster and cut more freely. If the wheel is breaking down too fast, decreasing the work speed will make the wheel act harder.

Always true a new wheel before staring to grind. It is very important to use a sharp diamond on small wheels. The small phonopoint diamonds are recommended for use on small wheels on long slender quills.

The length of the grinding stroke in relation to the length of the hole to be ground generally controls the straightness of the hole. On open or thru holes, the wheel should withdraw an equal amount from each end of the hole to avoid a tapered hole, the stroke should be adjusted to allow the wheel to withdraw from both ends of the hole approximately 1/4 inch for wheels 1/2 to 3/4 inch wide, and 1/4 to 3/8 inch for wheels wider than 3/4 inch. The wheels should never be withdrawn more than half the wheel width. If the wheel is wider than the length of the hole, the wheel should remain in the hole approximately the length of the work.

On blind holes, the wheel should not be withdrawn from the open end of the hole during the grinding cycle, if possible, to prevent grinding a tapered hole. If a recess or relief is not provided at the bottom of the hole, the stroke should be adjusted to reverse the stroke just before touching the bottom of the hole on the roughing part of the grind cycle. When finish grinding, the wheel can be fed manually past the reversing dog to clean up the stock left in the bottom corner of the hole.

Traverse speeds and feed are generally controlled by the characteristics of the job, the material, hardness, length and diameter of the hole, tolerances, etc. The traverse speed should be in proportion to the finish required and the width of the grinding wheel. The wheel infeed or depth of cut will vary with the material, hardness and finish required. As a general rule, feeds of .0005 for each pass is satisfactory, except when rigidity of quill, or lack of it, makes it necessary to reduce feed or makes it possible to take heavier cuts.

Whenever possible internal grinding should be done wet. The coolant will help keep the wheel clean, improve finish and cool the work and wash away the grinding swarf.

The conventional automatic internal grinder has a constant rate of feed per stroke or pass of the wheel, regardless of the stock in the work or the resistance to penetration of the wheel. In the controlled force system of internal grinding, the cross feed screw and constant feed per stroke is replaced by a hydraulic cylinder, during the infeed part of the grinding cycle, which keep a controlled force or pressure against the grinding wheel.

The rate of stock removal per pass is controlled by the ability of the wheel to grind the material at a given pressure. With this method of grinding, the problem of spindle or quill deflection is greatly reduced or eliminated.

Internal Grinding Starting Grade Only

Ceramic (MSB) Recommended for Steels Harder Than 50RC

Wheel Diameter	Wheel Grade
1"	5MSB1201-M4-VSAE
2"	3MSB1001-L6-VSAE
3"	3MSB801-K6-VSAE
4"	3MSB801-J6-VSAE
5"	3MSB601-I6-VSAE

Internal Centerless Grinding

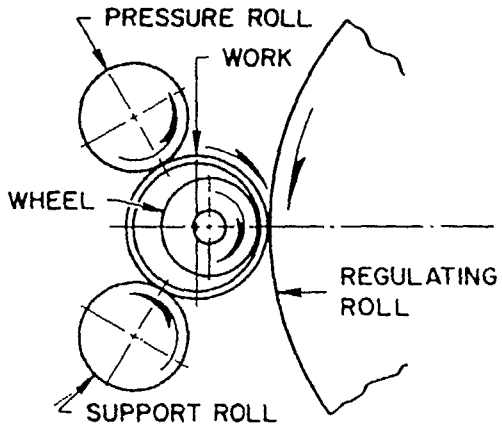
This method does not use a chuck and has no fixed centers; the work rolls on its own O.D. The bore is generated from the O.D., producing good concentricity between I.D. and O.D. The set-up consists of a regulating wheel, a support roll, and a pressure roll. the work must be cylindrical on the outside.

The regulating roll drives the work and also acts as a brake, preventing the work from being driven by the grinding wheel. The support roll is fixed below the work, and the pressure roll is mounted on a swinging arm that holds the work in contact with the regulating roll and support roll.

When work support shoes are used instead of rollers, the work is driven by a rotating back plate.

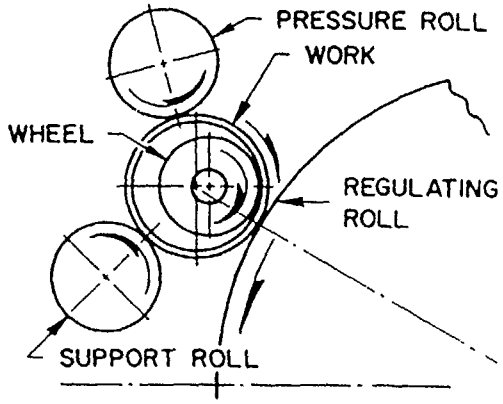
The internal centerless grinders are generally classified as "On-center work roll arrangement" or "Off-center work roll arrangement."

On-center machines have the rolls positioned so that the work, grinding wheel and regulating roll are all on the same centerline (note Sketch #1).



With this set-up the maximum support is given to the work and you can accurately grind parts that have a thin wall section with very little or no distortion.

Off-center machines have the work support rolls positioned so that the grinding wheel centerline is above the work regulating roll centerline (note Sketch #2).



Due to the angular relationship of the regulating roll and support roll, successively loaded parts even with some variation in O.D., are on the same vertical centerline, making it possible to grind such parts to close tolerances.

This type of internal grinder works exceptionally well to grind rings, sleeves, bearing cups and cones, cylinder liners, etc., and can be equipped to operate automatically when grinding small parts. Parts too large to be loaded automatically can be ground, but must be inserted manually one at a time.

Wheel Selection:

MSB wheels have shown tremendous improvements on most internal applications. The same rules for determining size still apply and most grades are in 3 or 5MSB, 80-120 Grit, I thru N grades, depending on the part size.

Since the commercial introduction of CBN by General Electric in 1969, the use of this abrasive has grown at a steadily expanding rate. After considerable research and experimentation, it was found that CBN wheels could be used successfully for internal grinding operations. Cincinnati Milacron was a pioneer in bore grinding development with vitrified CBN. Today, Milacron continues its leadership position by introducing new products such as Marathon 2.

The advantages which CBN abrasives bring to other forms of grinding also apply to internal grinding operations:

- High stock removal
- Long wheel life / High G-Ratio
- Greater precision, better quality
- Increased productivity
- Lower total cost per piece

Machine Specifications

Modern abrasives (superabrasives) and machines have developed the art of grinding into a highly efficient production tool. Work tolerances on a production basis have gradually been reduced from one thousandths of an inch to a few millionths of an inch.

Surface quality is now consistently measured and produced in microinches. All this has been possible because of the new abrasive products which were developed and the special grinders which were designed for superabrasive wheels to produce accurate parts and reduce grinding costs.

Internal machines should be complete with the following capabilities to optimize the use of CBN:

- Rigid designed spindle and work fixture
- Higher than normal wheels speeds ≥6500-12,000 SFPM
- Accurate feed systems
- Grinding fluid
- Rotary diamond dresser
- If possible, in process and post process gaging

Wheel Selection

Any successful grinding operation depends on choosing the right wheel for the job. The wheel selected will affect the material removal rate and the life of the grinding wheel. the selection of a CBN wheel should be thought out carefully. Like conventional wheels there are several factors to consider. With CBN there are two additional items to decide upon — concentration and depth of useable abrasive.

Wheel Grade Variables

I. Grain Type

- 2BN uncoated crystal — CBN vitrified
- XBN* microcrystalline crystal — CBN
- IBN nickel coated — CBN resin
- RD uncoated crystal — diamond/vitrified
- MD uncoated crystal — diamond/resin
- CMD nickel coated crystal — diamond/resin
- DMD nickel coated crystal — diamond/resin
- EMD nickel coated crystal — diamond/resin
- AMD copper coated crystal — diamond/resin

Listed above are the most common diamond and CBN crystals used by Milacron. However, for internal grinding of ferrous materials 2BN is used in vitrified bonds exclusively. RD diamond is used in vitrified bonded diamond of grinding non-ferrous materials.

II. Grit Size

CBN abrasive grit size greatly influences material removal rates and surface finishes. For high material removal rates, use coarse grit size wheels. For good surface finishes use finer mesh size.

CBN Mesh Size Range			Expected Finish
46		Resin Bonds	35 RA
60	Vitrified Bonds	Resin Bonds	32
80	Vitrified Bonds	Resin Bonds	24-30
100	Vitrified Bonds	Resin Bonds	22-24
120	Vitrified Bonds	Resin Bonds	20-22
150	Vitrified Bonds	Resin Bonds	18-20
180	Vitrified Bonds	Resin Bonds	16-18
220	Vitrified Bonds	Resin Bonds	14-16
240	Vitrified Bonds	Resin Bonds	12-14
280	Vitrified Bonds	Resin Bonds	10-12
320	Vitrified Bonds	Resin Bonds	8-10
400	Vitrified Bonds	Resin Bonds	6-8
Finer 400		Resin Bonds	4-6
Finer 400		Resin Bonds	4-6
1200		Resin Bonds	2-4

**XBN used largely for alternate CBN types.*

III. Hardness

Hardness is determined by the percentage of bond present in the wheel composition. Hardness dictates the strength or tenacity of grinding action. Marathon and Marathon 2 have different ranges of hardness which enhance the performance.

MARATHON® P R T U

SOFT ◄——► HARD

MARATHON 2™ M N O P

Hardness should be varied depending upon the stock removal rate required, wheel life expected and De (arc of contact).

IV. Concentration

Concentration can be described as the number of superabrasive particles per cubic inch of resin material. The higher the concentration the longer the wheel life. Higher concentration will also increase the normal and tangential grinding forces. A rule of thumb is to use low concentration wheels for low stock removal and large areas of contacts while using high concentration for high stock removal and smaller areas of contact.

Vitrified Range

- 80 20% by volume 57.6 cts/in³
- 100 25% by volume 72 cts/in³
- 125 31.25% by volume 89.9 cts/in³
- 150 37.5% by volume 107.9 cts/in³
- 164 41% by volume 118.0 cts/in³
- 175 43.75% by volume 125.9cts/in³
- 200 50% by volume 144 cts/in³

Resin Range

- 44 11% by volume 31.6 cts/in³
- 66 16.5% by volume 47.4 cts/in³
- 80 20% by volume 57.6 cts/in³
- 88 22% by volume 63.3 cts/in³
- 100 25% by volume 72 cts/in³
- 125 31.25% by volume 89.9cts/in³

IV. Bond Type

The four bonds used with superabrasive wheels are resin, metal, electroplated, and vitrified. Vitrified bonds are used for most production bore grinding operations. Resin and metal are used where fast removal and durability are required. Electroplated is used where high stock removal is needed with no significant requirement on tolerances and/or surface finish.

Vitrified bonds provide the best bond type for production bore grinding applications. Vitrified bond is the only type which contains porosity and the necessary chip clearance while yielding extremely tight tolerances and finishes below 32RA.

C.M.P.D. Vitrified Bond Types

Marathon

VHA — Al_2O_3 as secondary abrasive
VHC — SiC as secondary abrasive
V — no secondary abrasive

Marathon 2

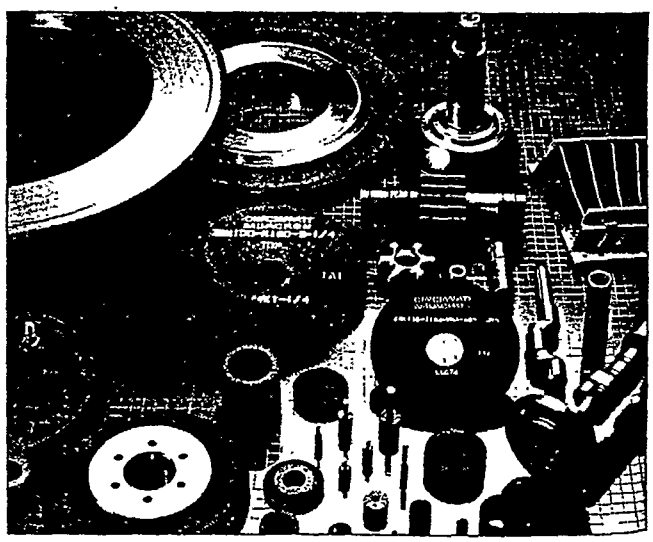
VEA — Open structure with Al_2O_3 as secondary abrasive
VEC — Open structure with SiC as secondary abrasive
VEB — Open structure with no filler

Marathon 2 with patented filler

VMA — Open Structure with Al_2O_3 and patented filler
VMC — Open structure with SiC and patented filler
VMB — Open structure with no filler and patented filler

Depth of Abrasive

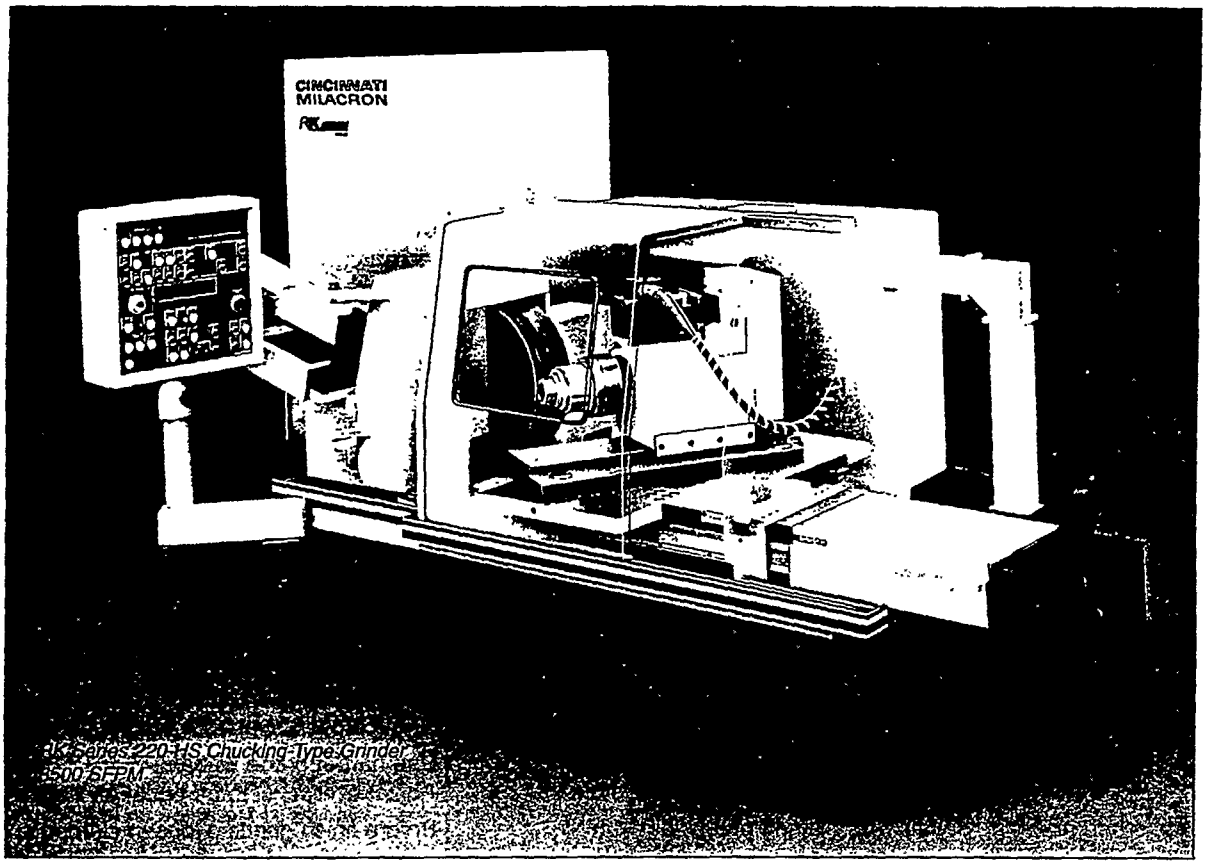
Normally a wheel for bore grinding <.500" will be made as a solid superabrasive wheel. Wheels larger than .500 will generally have a 1/16 or 1/8 useable rim. This is designated with a depth marked on the end of a wheel specification. EXAMPLE: 2BN100-R100-VHA1/8.



MIL 000166

Problem	Possible Causes	Suggested Correction
1. Feed lines or spirals on workpiece	Poor wheel dressing. Wheel too hard. Wheel head tipped.	Redress wheel carefully. Use softer wheel or reduce wheel feed. Realign wheel head.
2. Scratching of work	Wheel too soft. Faulty wheel dressing. Wheel too coarse. Dirty coolant.	Use harder grade wheel. Check for cracked or loose diamond and redress. Use finer grit wheel. Change coolant.
3. Burning of workpiece	Wheel too hard. Work speed too slow. Wheel infeed too fast. Poor coolant flow.	Use softer grade wheel. Increase work speed. Reduce wheel infeed. Ensure coolant directed at grinding contact.
4. Wheel glazing (shiny appearance)	Wheel too hard. Wheel too fine. Poor wheel dressing. Poor quality/quantity coolant.	Use softer grade wheel. Use coarser grit wheel. Check diamond sharpness - redress. Reduce oil level - increase amount of coolant.
5. Wheel loading (metal lodged in wheel pores)	Wheel too fine. Wheel too hard. Wheel too finely dressed. Poor coolant flow. Insufficient wheel breakdown.	Use coarser grit wheel. Use softer grade wheel. Give a more open dressing to wheel. Increase supply and clean coolant. Increase work and traverse speed.
6. Bell-mouthed hole	Tipped workhead. Misalignment of center heights. Overtraveling of wheel.	Realign workhead. Carefully "zero" centers. Reduce overtravel from both ends.
7. Tapered hole	Wheel too soft. Uneven travel past each end of hole.	Use harder grade wheel. Adjust overtravel to be equal on both ends.
8. Out-of-round hole	Overheated during previous rough grinding and became distorted. Rotating fixture out of balance. Hole distorted after front face grinding.	Before finish grinding loosen clamps and retighten one at a time. Balance rotating fixture. Grind front face before grinding the hole.
9. Chatter marks	Wheel too hard. Spindle material not rigid enough. Defective belt. Wheel out of balance or truth. Dust or other particles inside wheel pulley. Worn spindle. Machine not on solid foundation.	Use softer wheel. Replace spindle. Replace belt. Balance and/or true wheel . . .avoid use of bushed wheels. Clean inside surface of pulleys. Replace spindle. Assure machine is properly aligned and not adjacent to heavy vibrating machines.

9 MICRO-CENTRIC and Chucking Grinders



K-Series 220-HS Chucking-Type Grinder, 8500 SFPM

Brief Specifications[1]

Work Capacity

Work Diameter Range	0.5 to 7.1" (12 to 180 mm)

Grinding Wheel

Maximum Diameter	24" (609 mm)
Minimum Diameter	17" (431 mm)
Hole Size	12" (304 mm)
Width (Max.)	4" (102 mm)[2]
Motor	20 hp (15 kW)
Surface Speed With New Wheel	8500 sfpm (43 m/s)

Headstock

Speed Range	Variable, 30 to 600 rpm
Orientation	0° or 30°
Motor	1 hp (0.7 kW)

[1] Specifications subject to change without notice

[2] Consult factory for wider wheel widths

MIL 000168

Cincinnati Milacron's new RK Series 220-HS Chucking-Type Grinder brings precision, high-volume infeed grinding to round parts whose flanges and other irregularities make centerless and centertype grinding impractical.

Built to complement the proven RK Series Centerless Grinders, our standard 20 hp (15 kW) 220-HS, featuring a variable speed headstock (HS) work drive system, is ideally suited for grinding diameters, shoulders, tapers, radii, grooves and similar operations without sacrificing high production.

And like the RK Centerless, the simplicity designed into the 220-HS contributes directly to its overall reliability, durability and ease of operation. Simple modular build and mechanical design combine with advanced features to make these machines remarkably accurate and affordable.

Sturdy, Smooth Running Headstock

The variable speed servomotor work drive system has a broad range of part rotational speeds programmable in revolutions per minute. To assure a high degree of grinding accuracy, the drive plate rotates on precision taper roller bearings that are lubricated for life. No maintenance required here.

"Standard" 220-HS models feature 0° or 30° headstock orientation though machines can be built to any custom angle within this range.

Work can be mounted in chucks or draw-in collets.

Precision Components

RK Series 220-HS machines are built on an epoxy granite base, selected for its superior rigidity, vibration damping and thermal characteristics.

Infeed axis feed slide combines anti-friction ways, brushless AC servomotors, precision ballscrews and digital feedback. The result gives you compensation with 0.000004" (0.1 micron) resolution.

The FILMATIC cantilever-style grinding wheel spindle bearing system with hydrostatic lift provides long-lasting, hydrodynamic, self-centering support which is consistent under varying grinding loads. High dynamic and static rigidity provide 0.000004" (0.1 micron) rotational accuracy.

CNC or cam-type anti-friction profile grinding wheel truing with selectable rate servomotor-driven traverse and diamond axes provide 0.000004" (0.1 micron) resolution.

DMC Grinding Control

The Multi-Axis DMC (Dedicated Motion Controller) is the standard system for all RK Series Grinding Machines. It's a small unit with relatively few controls — easy to learn, easy to set up and easy to operate — yet packed with flexibility.

Comprehensive diagnostics and cycle status display provide detailed operator information. Simple, direct controls give you the accuracy, speed and consistency of servo control with the common sense operation of a manual machine.

Commonality and Support

Incorporating many of the same components as the RK Centerless, the 220-HS uses 95% identical and interchangeable electronics, truing unit, feed motor and ballscrews to make maintenance easy for users of existing RK machines.

Milacron has the machines, controls, wheels, fluids, training, service, parts and process expertise, providing a total support package that's second to none.

Grinding Wheel Grades

- General Purpose — 97A601-K6-VFME
- Precision Finishing — 29A801-J4-VRWE
- Ceramic — 3MSB801-J6-VSAE

Larger diameter parts require slightly softer grades.

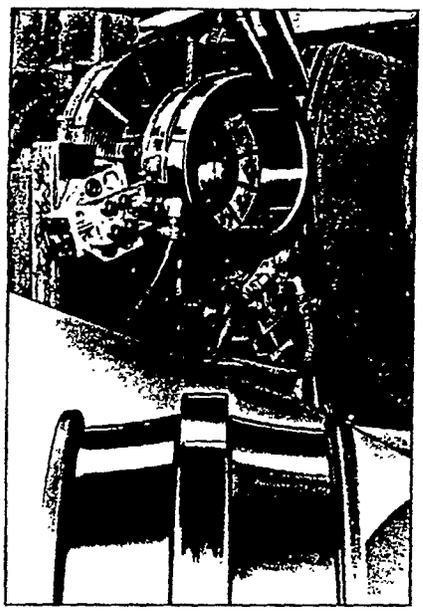
Standard Machine Features

- Epoxy granite machine base
- Anti-friction slide-way systems throughout
- Simple, precise DMC (Dedicated Motion Controller)
- 0.000004" (0.1 micron) machine resolution
- Multi-axis servomotor machine motions
- FILMATIC grinding wheel spindle bearings
- Externally mounted grinding wheel motor
- Isolated stand-alone hydraulics
- Machine mounted electrical cabinet
- Variable speed servomotor work drive system
- 0° or 30° Headstock orientation
- Totally enclosed grinding zone

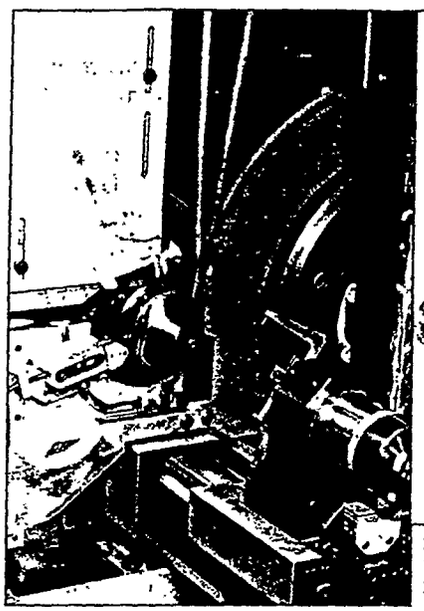
Optional Equipment

- Various work holding devices
- CNC grinding wheel truing
- Rotary diamond roll grinding wheel plunge dresser
- Variable frequency grinding wheel drive
- Automatic grinding wheel balancer
- Automatic gaging systems
- Coolant filtration and refrigeration equipment
- Auto-loaders
- Various Programmable Controller alternatives

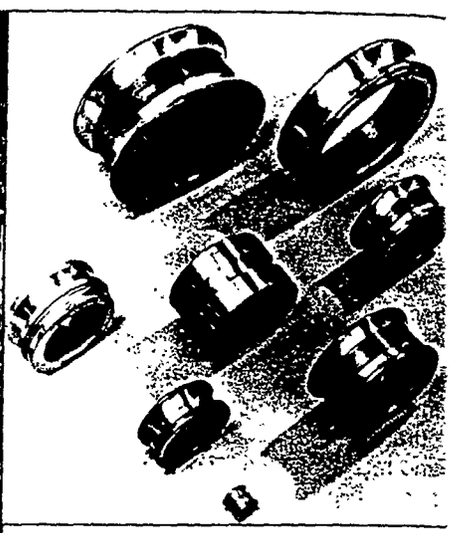
MICRO-CENTRIC



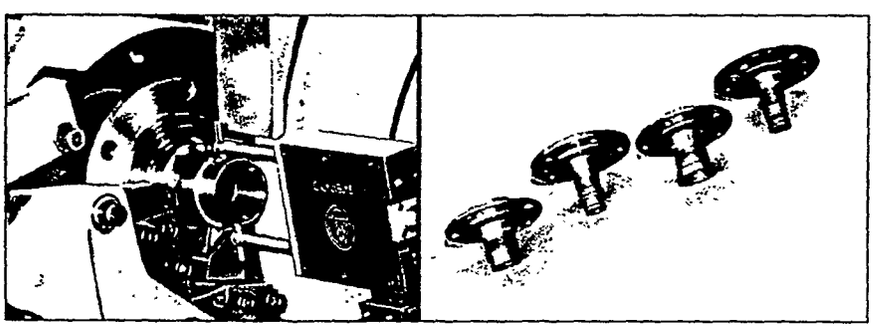
29A1001-J6-VAE
Grinding two track bearings simultaneously requires special radius truing unit.
3MSB1001-I6-VSAE



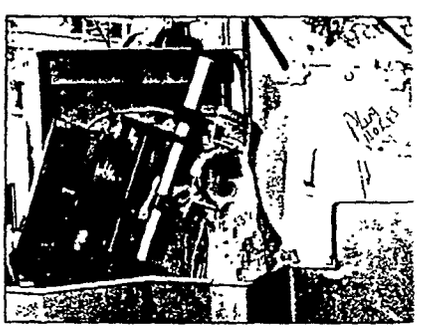
29A801-K4-VAE
A variety of bearing races are ground on this No. 1 MICRO-CENTRIC.
3MSB801-J4-VSAE



29A1001-N4-VFME
12A1201-L4-VRW
3MSB1201-L4-VSAE

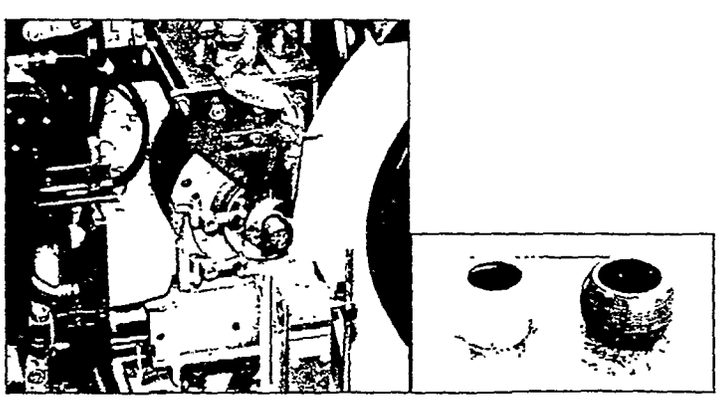


29A801-J4-VFM
Shoe-type centerless grinding a variety of automotive front wheel spindles.
3MSB801-J4-VSAE



29A1001-K4-VFME
Face and OD of large outer bearing are ground simultaneously.
3MSB1001-J4-VSAE

Chucking

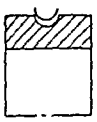


97A1001-K4-VRWE
Formed wheel automatic grinds centering balls
3MSB1001-J4-VSAE

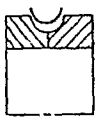
MIL 000170

Numerous applications have been effectively processed on MICRO-CENTRIC Grinders. The following illustrations show some examples of the machine capability and factory-based process knowledge which support your Cincinnati Milacron Marketing Company Field Engineer's recommendation for a machine to tackle your production requirements.

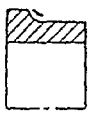
Ball Tracks



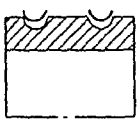
Part Range: .5" to 4.5" diameter
Machine: No. 1 MICRO-CENTRIC
Truing: Common Carrier Radius, 0 to .875" convex or Rotary Diamond Cartridge
Part Range: 2" to 10" diameter
Machine: No. 2 MICRO-CENTRIC
Truing: Common Carrier Radius, 0 to .875" convex or Rotary Diamond Cartridge



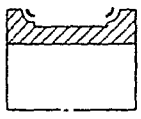
Part Range: .5" to 4.5" diameter
Machine: No. 1 MICRO-CENTRIC
Truing: Common Carrier Radius, 0 to .875" convex (Reciprocator for lateral spindle feed)



Part Range: 2" to 10" diameter
Machine: No. 2 MICRO-CENTRIC
Truing: Common Carrier Radius, 0 to .875" convex



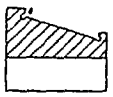
Part Range: .5" to 4.5" diameter
Machine: No. 1 MICRO-CENTRIC
Truing: Dual Position Radius, 0 to .750" convex or Rotary Diamond Cartridge



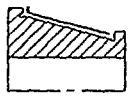
Part Range: .5" to 4.5" diameter
Machine: No. 1 MICRO-CENTRIC
Truing: Dual Position Radius, 0 to .750" convex or Rotary Diamond Cartridge

Tapered

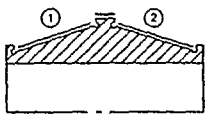
Part Range: .5" to 4.5" diameter
Machine: No. 1 MICRO-CENTRIC
Truing: Profile — Sine Bar Attachment (straight or crowned taper)
Part Range: 2" to 10" diameter
Machine: No. 2 MICRO-CENTRIC
Truing: Profile — Sine Bar Attachment (slight or crowned taper)



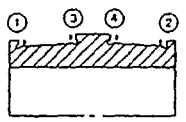
Part Range: .5" to 4.5" diameter
Machine: No. 1 MICRO-CENTRIC
Truing: 30° Angular-Double Diamond Holder



Part Range: .5" to 4.5" diameter
Machine: No. 1 MICRO-CENTRIC
Truing: Double Angle
Part Range: 2" to 10" diameter
Machine: No. 2 MICRO-CENTRIC
Truing: Double Angle



Part Range: .5" to 4.5" diameter
Machine: No. 1 MICRO-CENTRIC
Truing: Profile
Part Range: 2" to 10" diameter
Machine: No. 2 MICRO-CENTRIC
Truing: Profile



Part Range: 2" to 10" diameter
Machine: No. 2 MICRO-CENTRIC
Truing: Ball Bushing Profile (4 operations)

MICRO-CENTRIC & Chucking Grinder Wheels Commonly In Stock In Various Grades — 29A, 97A, MSB

24 x 3 x 12	20 x 1 x 12
24 x 2 x 12	20 x ½ x 12
24 x 1 x 12	20 x ½ x 12
24 x ½ x 12	18 x 1 x 12
20 x 2 x 12	18 x ½ x 12

MIL 000171

Race Grinding (Bearings)

Race Grinding refers to the precision form grinding of outer and inner ball of roller bearing "Raceways" (usually referred to as the "Ball Track" and the "Roller Path").

Wheels used for internal grinding the raceway in the outer ring are normally Type 1 straight wheels with special faces formed to the contour of the raceways. Wheels range from approximately 1/2" to 6" in diameter. thicknesses are determined by the width of the raceways, and are always specified decimally. One special application, called "Cross-Axis" grinding, involves grinding the inside diameter of large spherical roller bearing "outers." This employs the use of the rim (outer edge) of a Type 6 Cup Wheel where the axis of the wheel is at 90° to the axis of the workpiece.

External grinding of the matching raceway in the "inners" is usually performed with wheel sizes ranging from 14" to 24" diameter. The wheel face thickness (specified decimally) is again determined by the width of the raceway. Type 1 straight wheels, or wheels with a hub on one side, are used with formed faces to suit the raceway form. Hubbed wheels are used where the required face thickness cannot be manufactured in a straight wheel and/or where the grinder requires a certain minimum thickness for mounting.

Standard operating speeds are 6500 SFPM and 8500 SFPM, with special high production applications on high performance machines operating as high as 16,000 SFPM on external grinders. Where speeds above 8500 SFPM are required, special speed approvals are necessary. Consult your Cincinnati Milacron Marketing Company Sales Representative.

Specification Selection Guide

For AISI-52100 and AISI-8620 Heat Treated (R_C 62 to 64)

Internal (I.D. of Outers)	Wheel Specifications	
Application	Less Than 3" Diameter	Diameters over 3" thru 6"
Ball tracks (plunge)	97A1201-L4-VFMD2E	97A1001-K6-VFMD2E
Ball tracks	97A1201-L6-VFM	97A1001-K6-VFM
Roller paths	97A801-K6-VFMD2E	97A801-J6-VFMD2E
Cross-Axis (cups) for high finish	9A70-I6-VFM	9A70-I6-VFM

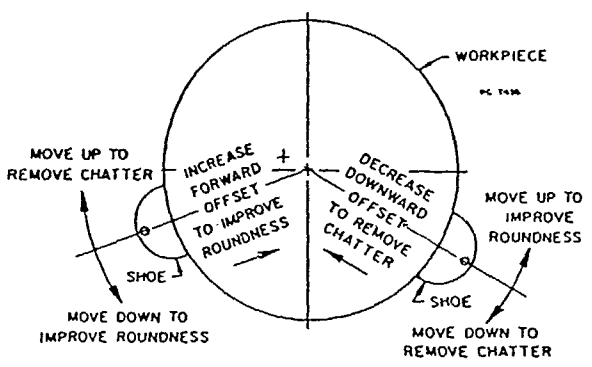
External (O.D. of Inners)	Wheel Specifications 12" thru 24" dia. wheels	
Application	½" thick & less	Over ½" thick
Ball tracks (plunge)	97A1001-L4-VFM	9711001-K4-VFM
Ball tracks	97A1201-K4-VFM	97A801-J4-VFM
Roller paths	97A1001-K4-VFM	97A1001-J4-VFM
When using VRW or VQC go 1 grade softer.		

Set-Up Hints for MICR0-CENTRIC Grinding

1. Check for proper offset.
2. Good starting point .010" down .015" forward.
3. Remember that as the part is ground to size downward offset increases — forward offset decreases.
4. The larger the diameter of the part the greater the offset. The smaller the diameter of the part the smaller the offset.
5. Set rear shoe approximately 15° to 20 down from centerline of part.
6. Set front shoe as close to grinding wheel as possible.
7. Remember that on larger diameter parts, the front shoe must be moved away from grinding wheel to prevent chatter.
8. Be sure that face of driver is square with axis of grinding wheel spindle.
9. Lowering headstock RPM will decrease chatter.
10. Raising headstock RPM will increase roundness.

Alternate Grades	
29A1201-L4-VRWE	3MSB1201-K4-VSAE
29A801-K4-VRWE	3MSB801-J4-VSAE
29A1001-L4-VRWE	3MSB1001-K4-VSAE
For parts 3"-6" diameter use 6 structure	

MICRO-CENTRIC Set-Up Diagram



Typical Machine Manufacturers

Bryant Landis Cincinnati

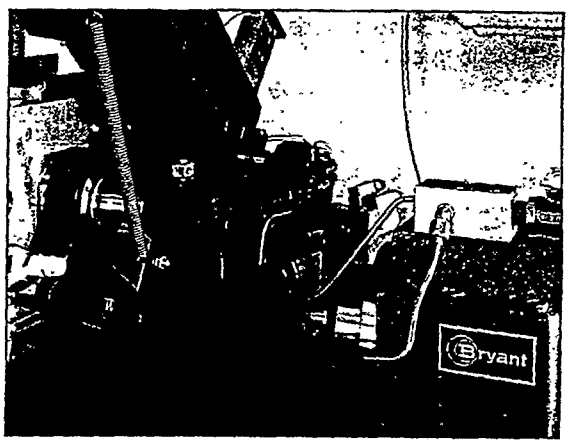
Internal Race Grinding Machines (Refer to Internal Grinding Section)

External Race Grinders

Bryant Grinder Corp., Springfield, VT

Machine/Model	Wheel Size			SFPM
	D	T	H	
MCM External Chucker	6-20	1¾ max.	1½-12*	8,500, 12,000, 16,000
CENTRA-FORM	20	1¾ max.	12*	8,500, 12,000, 16,000

*Note:Wheels with 12" nominal holes frequently have decimal oversize based on wheel speed: 8,500 SFPM and less — 12.000 hole; 12,500 SFPM — 12.050 hole

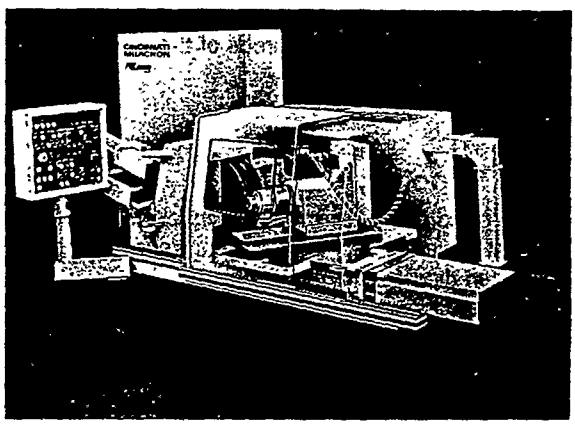


Bryant's new model Ultraline Internal Grinder. Metal bond diamond cup dresser capable of using vitrified and resinoid CBN grinding wheels. Typical grade for this type of grind is 2BN150-M164-VMB

Cincinnati Milacron, Cincinnati, OH

Machine/Model	Wheel Size			SFPM
	D	T	H	
MICRO-CENTRIC #1	20	1 max.	12	6,500
MICRO-CENTRIC #2	20	2 max..	12	6,500
MICRO-CENTRIC #1MM	6-20	1.5 max.	up to 12*	12,000 & 16,000
MICRO-CENTRIC #1MD and #2MD	20 24	2 max. 3 max.	12 12	8,500 & 12,000 8,500

*Note: 20" diameter wheels for the Model #1MM may also be supplied with 11" holes.



Cincinnati Milacron's RK Series 220-HS Chucking-Type Grinder.

Landis Tool Co., Wayneboro, PA

Machine/Model	Wheel Size			SFPM
	D	T	H	
#2 RACE-A-WAY	12	3/16-1	5	11,200
Concentric Type R	16	1	8	Special*
Conjugate 4.8 type R	6	1	1¼	Special*

*Note: Refer to manufacturer's specifications on machine rating plate.

MIL 000173

1. Type of parts. Bearing parts, races, rollers, cups, small pistons, gears, nozzles, etc.

Micros and chuckers are a necessity on high production of parts difficult to hold. Most micros use the shoe type holder; most chuckers employ some type of chuck.

2. Selection of Grinding Wheel
   A. Things to consider:
      1. Roughing or finishing
      2. Hardness of part
      3. Cycle time
      4. Type of dresser
      5. Finished part criteria
   B. Steps to take:
      1. For roughing, use 60-80 grit; for finishing use 80-120 grit.
      2. For soft material, coarse grain and harder grades can be used, i.e. 46-60 in K-M grades. Tough abrasive may also be used (2A).
      3. For hard material, finer grain and softer grades must be used, i.e. 80-120 in I-K grades. Most work on Micros is hard and requires more friable grain (29A).
      4. Cycle times are usually short, thus the need for this type of grinder. This is especially valuable in bearing plants where production runs may consist of hundreds of thousands of parts.
      5. Listed below are 2 sets of conditions one may encounter and the proper Cincinnati wheel and coolant.

Recommendation To Do The Job

Soft Part	Hard Part
Part: Race	Race
Hardness: 35-40	60-62
Stock: .025	.010
RMS Finish: 32 micro inch	12 micro inch
Waveometer: N/A on soft parts	4-5 hi band
Machine Speed: 8500 SFM	8500 SFM
Wheel: 97A701-N4-VFME	29A1001-L4-VFME
Cimstar 60 LF	Cimstar 60 LF
CIMPERIAL 20 at 1-20	CIMPERIAL 20 at 1-20

The part size has a direct effect on the wheel grading. A smaller part with sharper arc of contact may require a harder wheel. A larger part with more contact area, may require a softer wheel.

Trouble Shooting

Precision grinding with micros and chuckers employs a unique set of variables. Part sizes can range from 1/4" to 10" or 12" in diameter. Wheel diameters can vary from 6" to 24". Wheel speeds can vary from 6500 SFM to 16,000 SFM. Any of these factors have a noticeable effect on the grinding operation.

For large diameter parts, you must use sharp grain, softer grades, and more open structures.

Listed below are some problems and some helpful hints for solving them.

PROBLEM	CAUSE
Poor Finish —	Wheel too soft
	Diamond traverse too fast
	Cycle time too short (add sparkout)
	Not enough grinding fluid or wrong grinding fluid
	Check hardness of part
Out of Round —	Wheel too hard
	Cycle time too short (add sparkout)
	Not enough grinding fluid
	Dull diamond
	Check hardness of part

Check Helpful Hints Guide on back cover.

10 Surface Grinding

Recommended Starting Grades For Surface Grinding

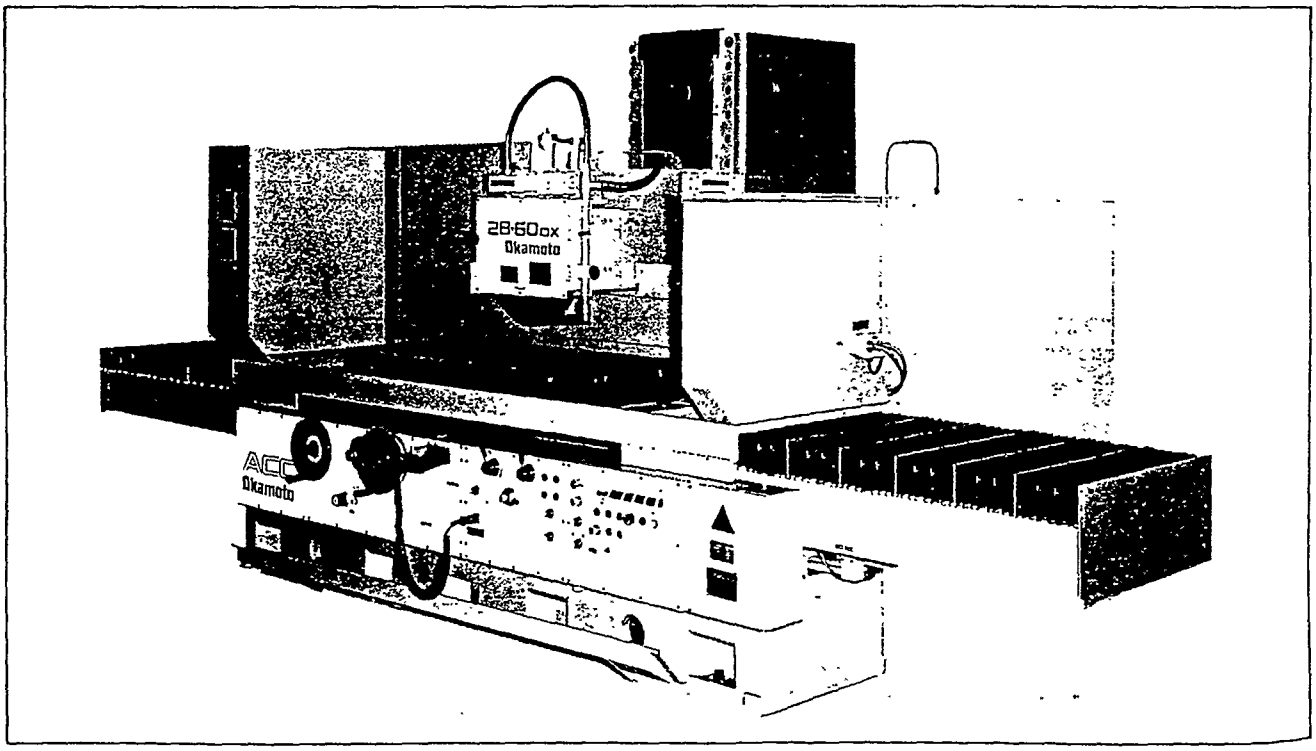
Horizontal Spindle Reciprocating Table Surface Grinders.

Material	Wheels Less Than 16" Diameter	Wheels 16" Diameter and Over
Cast Iron	97A361-H10-VA	97A361-G10-VA
Nonferrous Metal	6C36-J6-VSC	6C36-J6-VSC
Soft Steel	12A46-J6-VA	12A46-J6-VA
Malleable Iron & Steel Casting	97A461-J4-VFM	97A361-J4-VFM
Hardened Steel	12A46-H6-VA	12A36-H6-VA
Broad Contact	12A601-F10-VA	12A461-F10-VA
Narrow Contact or Interrupted Cut	12A461-I6-VA	12A461-H6-VA
Form Grinding		
Crush Dressing-Roughing	97A801-K4-VFM	12A801-K4-VFM
Crush Dressing-Finish	97A1201-J4-VFM	97A1201-J4-VFM
General Purpose	12A36-I6-VA	12A36-H6-VA
Cemented Carbide		
Roughing	5C60-J6-VSC	5C60-I6-VSC
Finishing	5C120-J6-VSC	5C120-I6-VSC
Finishing	MD150-N100-B 1/8	MD150-L100-B 1/8

Vertical Spindle Rotary Table Or Reciprocating Table Surface Grinders.

Material	Type 2 Cylinder Wheels	Type 5 Cup Wheels	Segments
Cast Iron	12A301-G10-VA	12A301-G10-VA	97A241-G10-VA
		6C24-I6-VSC	6C24-H10-VSC
Nonferrous Metal	6C24-I6-VSC	6C24-I6-VSC	6C24-I6-VSC
	12A30-H6-VFM	12A30-H6-VFM	12A241-G10-VA
Soft Steel	12A301-H6-VFM	12A241-I6-VA	97A301-G10-VA
	12A241-G10-VA	97A301-I6-VFM	12A241-H6-VFM
Malleable Iron &			
Steel Castings	97A241-H6-VFM	97A301-H6-VFM	2A301-F10-VFM
	12A301-F10-VA	12A241-G10-VA	97A301-F10-VA
Hardened Steel			
Broad Contact	97A461-H6-VA	12A461-H6-VFM	12A361-F10-VA
	97A461-F10-VA	12A601-F10-VA	12A361-H6-VA
Narrow Contact or			
Interrupted Cut	12A461-H6-VFM	12A461-H6-VFM	971461-I6-VA
	97A461-H6-VA	971461-H6-VFM	12A361-G10-VA
Cemented Carbide	5C60-J6-VSC	5C60-J6-VSC	5C60-J6-VSC
General Purpose	97A301-G10-VA	97A301-H6-VFM	97A301-G10-VA
	12A301-G10-VA	12A30-H6-VFM	12A341-G10-VA

MATERIAL	CERAMIC GRAIN SEGMENTS MEDIUM WORK AREA	SEGMENTS		RING & WHEELS MEDIUM WORK AREA
		SMALL WORK AREA	LARGE WORK AREA	
ALUMINUM	NO	WA242-G12-VC4 C54-G7-B290-XS (for 60 RMS)	WA242-G12-VC C54-G7-B290-XS	LA301-H8-VP
BOILER PLATE & SOFT STEELS 1018, 1020	3WB247-F12-VC4 If Hard Scale Only	WA242-B12-VC4	WA242-F12-VC2	LA301-G9-VP2
BRONZE	NO	WA242-G12-VC4	WA242-F12-VC2	LA301-G9-VP2
CAST IRON	3WB247-E12-VC2	WA242-G12-VC4	WA242-F12-VC2	LA301-G9-VP2
STEEL 1034 STEEL 4140 Tool Steel 55 to 62 RC	3WB302-E12-VC2 WB36-F12-VC 3WB302-E12-VC4	WA242-G12-VC4 JA46-G10-VP4 WA462-E12-VC2	WA242-F12-VC2 JA46-G10-VP WA462-E12-VC4	LA301-G9-BP2 LA301-G9-VP2 WA462-E12-VC4
STAINLESS STEEL Non-Magnetic 300 Series Heat Treated 400 Series Fine Finish 2 to 8 RMS	3WB302-E12-VC2 3WB302-F12-VC4	WA309-E9-V4-B WA301-H12-VC4 C180-B200-XS	WA301-G6-VR-B WA301-G12-VC2	WA301-G6-VR-B WA301-H8-VP2
GENERAL PURPOSE		WA242-G12-VC4	WA242-F12-VC2	WA301-G9-VP2



Okamoto Column Type ACC 28-60
Typical Wheel Size: 20 x 3 x 8
Typical Wheel Grade: WA461-F12-V4 or 9A461-G10-VA

MIL 000176

Material	Grade
Cast Iron	12A361-G10-VC
Nonferrous Metal	6C36-I6-VSC
Soft Steel	97A461-G10-VC
Malleable Iron & Steel Castings	97A361-H6-VFM
Hardened Steel	12A46-H6-VC
Broad Contact	12A461-F10-VC
Narrow Contact or Interrupted Cut	12A46-I6-VFM
Carbide	
Roughing	5C60-J60-VSC
General Purpose Grade	12A461-I6-VC

Form Grinding

Stainless Steels
- 300-400 Series
- Heat Resistant Ni Base
- Super Alloys
  - A 286
  - Inconel
  - Rene
  - Udimet
  - Waspalloy

General purpose wheel grading for these materials would be: 12A60-J6-VRW
12A54-J6-VRW

Specification Guide

Horizontal Spindle Grinders

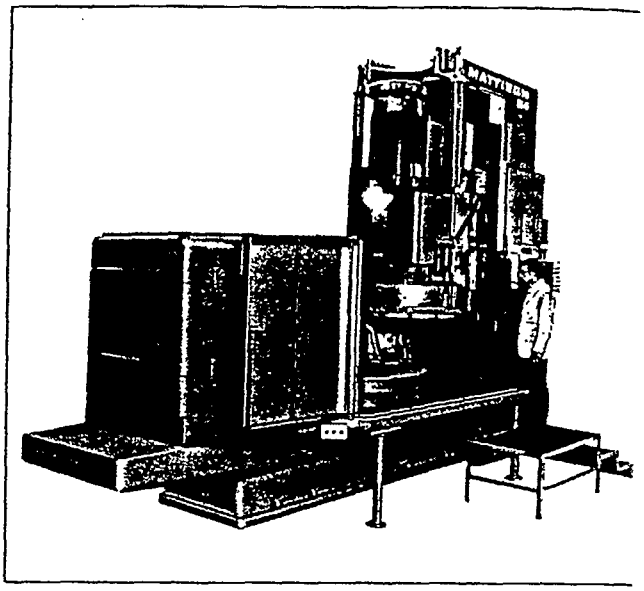
Application	Wheel Specifications
Alnico	9A80-H6-VA
Aluminum	6C36-J6-VSC
Brass	6C36-J6-VSC
Bronze	6C36-J6-VSC
soft	6C36-J6-VSC
hard	97A461-K6-VA
Cast Iron	
ductile	9A46-J6-VA
gray	9A46-J6-VA
chilled	6C46-J6-VSC
Nihard	9A46-I6-VA
Chrome plate	12A70-I6-VFM
Die steel	
hardened	9A60-F10-VA
annealed	9A46-I6-VA
Steel	
soft	9A36-J6-VA
hard	9A60-I6-VA
tool and high speed	9A60-G6-VA
300 series stainless	9A46-J6-VA
400 series stainless	9A46-J6-VA
Stellite	6C54-I6-VSC
Titanium	7C601-K6-VSC
Tungsten	7C601-K6-VSC

Vertical Spindle Grinders (cylinders, cups, and segments)

Application	Wheel Specifications
Aluminum	
plate	7C361-H10-VSC
cast	9A361-H10-VA
Brass	6C36-I6-VSC
Bronze	
soft	6C24-I6-VSC
hard	9A36-G6-VA
Cast Iron	
ductile	97A301-G10-VA
gray	97A301-G10-VA
chilled	6C361-I6-VSC
Nihard	9A36-F10-VA
Steel	
hard (broad contact)	9A36-E10-VA
hard (narrow contact)	9A46-G6-VA
soft	971241-G10-VA
tool and die	9A46-I6-VA
300 series stainless	9A46-F10-VA
400 series stainless	9A24-G10-VA

Typical Machine Manufacturers

Abrasive Machine	Heald
Arter (Sundstrand)	Hill Acme
Blanchard	KOLee
Blohm	Magerle
Boyar-Schultz	Mattison
Bridgeport	Norton Worcester
Brown and Sharpe	(Surface Grinders)
Cone Blanchard	Phinney
Diamond	Pratt & Whitney
DoAll	Speedfam
Elb	Sundstrand
Excello	Taft-Pierce
Gallmeyer and Livingston	Thompson
Grand Rapids	Universal Vise
Hanchett	O.S. Walker



Machine and Wheel Data

Segments, Cylinders And Cup Wheels

Abrasive Machine Tool Co., E. Providence, R.I.

Machine/Model	Wheel/Segment Size	Type
	5 x 3 x 3 W = 5/8", E = 1/2"	T-6
No. 33	6 x 3 x 3 W = 3/4", E = 1/2"	T-6
	5 x 3 x 3 3/4 Rim 5/8" Plate Mounted (5 x 1/8 x 1 5/8)	1P289
No. 34	6 x 3 x 4 1/2 Rim 3/4 Plate Mounted (6 x 1/8 x 1 5/8)	1P420
No. 34 and M34 (with 6" CORTLAND Chuck)	4 Segments 3 1/2 x 7/8 x 4	CD-6

MIL 000178

Cone Blanchard, Windsor, VT (formerly Blanchard Machine Co.)

Machine/Model	Wheel/Segment Size	Segment Number
No. 10 (with type 2 wheel)	10 x 4 x 8, 1" Rim	T-2
No. 10 (with STERLING Chuck)	6 Segments 4-15/16 x 1 x 4	STG 10
No. 11 (with type 2 wheel)	11 x 5 x 9, 1" Rim	T-2
No.11 (with 11" BLANCHARD Chuck)	4 Segments 6¼ x 1¼ x 5	BL 11
No. 11 (with 12" CORTLAND Chuck)	4 Segments 7½ x 1½ x 5	CD12
No. 11 (with 12" STERLING Chuck)	6 Segments 5-15/16 x 1¼ x 5	STG12
No. 16 (with type 2 wheel)	18 x 5 x 15, 1½" Rim	T-2
No. 16 (with 18" BLANCHARD Chuck)	6 Segments 7-1/16 x 1¾ x 6	BL18
No. 16 (with 18" CORTLAND Chuck)	4 Segments 11¼ x 2¼ x 5	CD18
No. 16 (with 18" NORTON Chuck)1½ Segments	8 Segments 5 x 1½ x 6	NO18
No. 16 (with 18" NORTON Chuck) 2¼ Segments	8 Segments 5-9/16 x 2½ x 6	NO18A
No. 16 with 18" STERLING	8 Segments 6-13/16 x 1½ x 5	STG18
	or 6-13/16 x 1½ x 6	STG18A
No. 16A, 16-A Dual and 16A2 (Automatics)	18 x 5 x 10, 4" Rim	T-2
No. 18 (with type 2 wheel) See Note	18 x 5 x 15, 1½" Rim	T-2
No. 18 (with 20" BLANCHARD Chuck)	8 Segments 5-11/16 x 2 x 6	BL20
NO. 18 (with 20" CORTLAND Chuck)	6 Segments 8 x 1⅞ x 6	CD20 old style
	5 segments 10⅛ x 2 x 6	CD20A new style
No. 18 (with 20" NORTON Chuck)	9 Segments 5 x 1½ x 6	NO20
No. 18 (with 20" STERLING Chuck)	9 Segments 6-13/16 x 1½ x 5 6-13/16 x 2 x 5 6-13/16 x 2 x 6	STG20 STG20A STG20B

Cone Blanchard (cont'd)

Machine/Model	Wheel/Segment Size	Segment Number
No. 27 (with 27" BLANCHARD Chuck)	8 Segments 7¾ x 2½ x 7	BL27
No. 27 (with 32" BLANCHARD Chuck)	8 Segments 9-9/16 x 2-11/16 x 7	BL32
	16 Segments 4½ x 3½ x 9	BLA32
No. 27 (with 36" BLANCHARD (Chuck)	10 Segments 8-7/16 x 3 x 8	BL36
	18 Segments 4½ x 3½ x 9	BLA36
No. 42-72 (with 42" BLANCHARD Chuck)	10 Segments 10⅛ x 3 x 8	BL42
	20 Segments 4½ x 3½ x 9	BLA42
No. 42-72 (with 42" CORTLAND Chuck)	10 Segments 11¼ x 3 x 6 11¼ x 3 x 8	CD42 CD42-3 CD42H-3
No. 48-96 (with 48" CORTLAND Chuck)	11 Segments 11¼ x 3 x 6 11¼ X 3 X 8	CD48 CD48-3 CD48H-3

Hanchett Mfg. Co., Big Rapids, MI

Machine/Model	Wheel/Segment Size	Segment Number
No. 24* & 24A2 (with ring wheel-mounting)	16 x 4, 2" rim nut inserted type	Eight ⅜" inserted nuts on 14" circle
No. 36 (with 18" chuck)	8 Segments 5 x 1½ x 6	HM18
No. 36, 36A and 36A2 (with 20" chuck)	8 Segments 5¹⁵/₁₆ x 2 x 6	HM20
No. 72 (with 20" chuck)	8 Segments 5¹⁵/₁₆ x 2 x 6	HM20

**Serial nos. 1-33 take 10 hole*

Hanchett (cont'd)

Machine/Model	Wheel/Segment Size	Segment Number
Piano Vertical Spindle		
18" Chuck Planer Type	8 Segments 5 x 2¼ x 6	HM18
NOTE: HANCHETT Model No. 3000 Horizontal Spindle Type		
Vertical Reciprocating		
No. 300 (with 14" chuck)	6 Segments 5⅛ x 1½ x 6	HM14
No. 400 (with 22" chuck)	8 Segments 6-11/16 x 2 x 6	HM22
No. 400S 32" chuck	12 Segments 6¾ x 2 x 7	HM32
Face Grinders		
No. 500 (with 30" chuck)	12 Segments 7-3/32 x 2 x 7	HA30
No. 600 (with 4" chuck)	15 Segments 8 x 3 x 7	HA44
No. 900 (with 36" chuck)	12 Segments 8 x 2 x 7	HA36
No. 1000 (with 30" chuck)	12 Segments 7-3/32 x 2 x 7	HA30
NOTE: HANCHETT Model No. 500 Horizontal Spindle Type		

Hill Acme Co., Cleveland, Ohio

Machine/Model	Wheel/Segment Size	Segment Number
23" Chuck	8 Segments 7⅛ x 2 x 7¼	HI23
26" Chuck	9 Segments 7⅛ x 2 x 7¼	HI26
32" Chuck	11 Segments 7⅛ x 2 x 7¼	HI32

Mattison Machine Works, Rockford, IL

Machine/Model	Wheel/Segment Size	Segment Number
No. 24D Duplex Rotary	18" Chuck 8 Segments 5 x 1½ x 6	HM18
	18 x 6 x 15, 1½" Rim Nut Inserted Type	T-2
24A & 24A2 Vertical Spindle Rotary Table	18 x 4 x 14 Nut Inserted Type - 2" Rim	T-2
	18" Chuck 8 Segments (5 x 1¼ x 6)	HM18
24 Vertical spindle Rotary Table	18" Chuck 8 Segments	MA 18 NO 18
	20" Chuck 9 Segments	MA20
	22" Chuck 10 Segments	
36", 36-48" 36A & 36A2 Vertical Spindle Rotary Table	18 x 2 x 14, 2" Rim Nut Inserted Type	T-2
	20 x 4 x 16, 2" Rim Nut Inserted Type	T-2
	26 x 4 x 22, 2" Rim Nut Inserted Type	T-2
	18" Chuck 8 Segments (5 x 1¼ x 6)	HM18
	20" Chuck 8 Segments (5-5/16 x 2 x 6)	HM20
36", 36-48" 36A & 36A2 Vertical Spindle Rotary Table	26" Chuck 10 Segments (6½ x 2 x 6)	HM26
	26" Chuck 12 Segments	MA26 NO26
	32" Chuck 14 Segments	MA32 NO32
	36" Chuck 16 Segments	MA36 NO36
	26" Chuck 6 Segments	CD26
	32" Chuck 7 Segments	CD32
	36" Chuck 8 Segments	CD36
60 Vertical Spindle Rotary Table	42" Chuck 10 Segments	CD42
	48" Chuck 11 Segments	CD48
No. 72 and No. 100 Vertical Spindle Rotary Table	20 x 3 x 16	
	20 x 3 x 16, 2" Rim Nut Inserted Type	
	20" Chuck 8 Segments (5-5/16 X 2 X 6)	HM20
No. 200 and 200A Series Vertical Spindle Reciprocating	10 x 4 x 8, 1" Rim Nut Inserted Type	

MIL 000182

Pratt & Whitney Co., Div. Niles-Bement-Pond Co., West Hartford, CT

Machine/Model	Wheel/Segment Size	Type	Segment Number
8" Vertical Spindle Rotary	8 x 3 x 4 8 x 3 x 6, 1" Rim 8 x 4 x 6, 1" Rim 10 x 4 x 8, 1" Rim	Type 2 Cylinder Wheels	T-1
12" Vertical Spindle Reciprocating	12 x 4 x 8 3/8		6Y-1537
1" Vertical Spindle Reciprocating (Cup Wheel) or Cylinder Wheel	14 x 4 x 10 3/8 14 x 5 x 11 11/2" Rim		6Y-1047
(with 14" NORTON Chuck)	6 Segments 5 x 1 1/2 x 6		NO14
14" Vertical Spindle Hydraulic Model D	8 Segments 5 x 1 1/2 x 6		NO18

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Thompson Grinder
(Waterbury Farrel Div. of Textron, Cheshire, CT)

Machine/Model	Segment Size	Segment Number
Type "C" HYDROVERT Vertical Spindle 12", 18", 28"	For 12" Cortland Chuck 4 Segments 7 1/2 x 1 1/2 x 5	CD12
	For 14" Cortland Chuck 4 Segments 8 7/8 x 1 3/4 x 5	CD14
	For 18" Cortland Chuck 4 Segments 11 1/4 x 2 1/4 x 5	CD18

Universal Vise and Tool, Parma, MI

Machine/Model	Wheel Size	Type
SWISHER		
Old	7 x 3 x 3.3, 1/2" or 5/8" Rim	T-6
New	8 x 3 x 3.3, 3/4" Back	

Thompson Grinder
(Waterbury Farrel Div. of Textron, Cheshire, CT)

Machine/Model	Wheel Size	Type
6" x 18" Vertical Spindle Reciprocating	5 x 3 x 2 5/8" Rim, 1/2" Back	T-6
	6 x 3 x 3 5/8" Rim, 1/2" Back	T-6 T-6

MIL 000183

Surface Grinding
Horizontal Spindle Straight and Recessed

Material			Specification
ALNICO			WA54-G12-VC
ALUMINUM			C37-I7-V8
BRASS and SOFT BRONZE			C36-I7-V8
BRONZE, Hard			WA543-I12-VC
CAST IRON			C46-I7-V8
CEMENTED CARBIDES			
Roughing			GC60-J9-VP
Finishing			GC102-I7-V8
COPPER			C30-I7-V8
GRANITE, Contour			C36-K7-V8
MEEHANITE			C30-J7-V8
STEEL			
D2 Air & Oil Hardened	LA462-H9-V2	LA462-I9-V	3WB462-H9-V
Hardened over 60 RC	LA54-G10-V	WA54-G12-VC	3WB542-F10-V
Soft & Stainless	WA54-H12-VC2	WA54-F12-VC2	3WB54H-12-VC
Very Hard 65 RC	WA54-E12-VF	WA54-F12-VC2	3WB100-I11-V2
Form Grinding	LA1001-J11-V	LA1001-K11-V	3WB100-I11-V2
GENERAL PURPOSE	WA543-Super	WA54-I12-VC	3WB54H-12-VC
GENERAL PURPOSE			
18" through 24" diameters	LA364-H8-V	2WB362-H9-V	

Vertical Spindle Rotary Table Surface Grinding Machines
Helpful Hints

Vital Statistics for Popular Segments and Wheels

Shape	Size Length Width Height	Area Sq. In. per Segment	Volume Cu. In. per Segment
AA1	$11^{15}/_{16}$ X $2^{1}/_{8}$ X 6	20.9	125
AA2	$6^{1}/_{2}$ X $1^{7}/_{8}$ X $5^{1}/_{2}$	10	55
BL18	$7^{1}/_{16}$ X $1^{3}/_{4}$ X 6	11.81	71.4
BL20	$5^{11}/_{16}$ X 2 X 6	10.5	63.1
CD18	$11^{1}/_{4}$ X $2^{1}/_{4}$ X 6	18.4	110.4
CD18-8	$11^{1}/_{4}$ X $2^{1}/_{4}$ X 8	18.4	110.4
CD18XT8	$11^{1}/_{4}$ X 3 X 8	26.8	177.9
HI26	$7^{1}/_{8}$ X 2 X $7^{1}/_{4}$	12.48	90.5
NO18	5 X $1^{1}/_{2}$ X 6	6.86	41.18
NO18A	$5^{9}/_{16}$ X $2^{1}/_{4}$ X 6	11.65	68.2
STG18	$6^{13}/_{16}$ X $1^{1}/_{2}$ X 5	9.7	48.6
STG18A	$6^{13}/_{16}$ X $1^{1}/_{2}$ X 6	9.7	58.3
STG20S	$6^{13}/_{16}$ X $1^{1}/_{2}$ X 5	9.68	58.1
Ring Wheel	11 x 5 x 9	31.4	157.1
Ring Wheel	18 x 5 x 10	175.92	879.6
Ring Wheel	18 x 5 x 12	141.37	706.85
Ring Wheel	18 x 5 x 15	77.75	388.75
Ring Wheel	20 x 5 x $16^{1}/_{2}$	100.34	501.7
Ring Wheel	20 x 6 x $16^{1}/_{2}$	100.34	602

Though all grinding could be called surface grinding, the term "surface grinding" is used to describe the grinding of flat surfaces. Surface grinding applications range from heavy, rapid stock removal operations to precision grinding jobs.

Among the numerous makes of surface grinders that are manufactured today, there are five principal types:

1. Vertical Spindle, Rotary Table uses segments or cylinder wheels. Most common type of machine is the single spindle machine. Roughing, semi-finishing and finishing of flat surface can be performed on small to very large work pieces on these machines.

2. Horizontal Spindle, Rotary Table uses wheel types 1, 5, or 7. Work pieces are mounted on a rotary table and grinding is performed on the periphery of the wheel. Grit sizes from 36 to 80 are commonly used and vitrified wheel grades of F to K are used.

3. Horizontal Spindle Reciprocating Table uses wheel types 1, 5, or 7 with grit sizes 36 to 80. Soft wheels with grades F to K are generally used. Workpieces move back and forth under the wheel and all grinding is done on the periphery of the wheel.

4. Vertical Spindle, Reciprocating Table uses cylinder or cup wheels. like 3 above, the work moves back and forth but all grinding is performed on the face of the wheel. Soft grades and coarse grit size wheels are normally used.

5. See disc grinding section for disc applications and theory.

Surface grinding is widely used in toolroom applications. See toolroom section for details on toolroom surface grinding.

Type I And Recessed Wheels

Abrasive Machine Tool Co., East Providence, R.I.

Machine/Model	Wheel Size	Type
No. 3	8 x 1/2 x 1 1/2	1
No. 3B and 3S	10 x 1/2 x 3 10 x 3/4 x 3 10 x 1 x 3	
No M3, M3S and 1 1/2	12 x 1/2 x 3 12 x 3/4 x 3 12 x 1 x 3	
No. 5	14 x 1 1/2 x 5	
No. 1218 HYDRABRASIVE	12 x 1 x 3 12 x 2 x 3 12 x 3 x 3	

Blohm (Germany)

Machine/Model	Wheel Size	Type
HFS 6-9-12-15	12 X 2 X 76MM (300 MM x 50 MM x 76 MM)	Rec. 2/Sides 5 1/4 x 3/8
SIMPLEX 5-7-9-11-75	12 x 2 x 76 MM (300 MM x 50 MM x 76 MM)	Rec. 2/Sides 5 1/2 x 1/2

Brown & Sharpe Mfg. Co., Providence, R.I.

Machine/Model	Wheel Size	Type
No. 2	7 x 1/2 x 1 1/4	1
No. 2B	7 x 1/2 x 1 1/4	
No. 5	10 x 3/4 x 3	

DoAll Company, Minneapolis, Minnesota

Machine/Model	Wheel Size	Type
D6-1, G-1	7 x 1/2 x 11/4	1
D8-1, G-10	10 x 3/4 x 3	
D8-3, D-10-1	12 x 1 x 3	
D-10-3	14 x 1 x 3	

Elb (Germany)

Machine/Model	Wheel Size	Type
SWH	8 x 1 x 51 MM (200 MM x 25 MM x 51 MM)	
	10 x 1 x 51 MM (250 MM x 25 MM x 51 MM)	
RUBIN	10 x 1 x 51 MM (250 MM x 25 MM x 51 MM)	1
	12 x 2 x 76 MM (300 MM x 50 MM x 76 MM)	1
SWN, SWE, SWBE	12 x 2 x 76 MM (300 MM x 50 MM x 76 MM)	
SWE-O	14 x 4 x 127 MM (350 MM x 100 MM x 127 MM)	
SWBEO	16 x 4 x 127 MM (400 MM x 100 MM x 127 MM)	Rec. 2/Sides 7½ x ⅞
SWBDO	20 x 6 x 203 MM (500 MM x 150 MM)	Rec. 1/Side 12 x ¾ O/Side 12 x 1¼

Excello, Detroit, Michigan

Machine/Model	Wheel Size	Type
Style 85-Two Wheel Form	24 x □ x 12	1
Style 84-Single Wheel Form	12 x □ x 5	1
Angular Twin Head	12 x □ x 5	1

Gallmeyer & Livingston Co., Grand Rapids, Michigan

Machine/Model	Wheel Size	Type
No. 3V	5 x 3 x 3	6Y-171
No. 4	10 x ¾ x 2	
No. 5, 15 and 18	10 x 1 x 2	
No. 20	7 x ½ x 1¼	1
No. 25	or 8 x ½ x 1¼	
No. 28	10 x ¾ x 1½	
No. 35 and 38	10 x 1 x 2	
No. 45, 45A, 45B, 55, 55A 55B, 65, 65A	12 x 1 x 3	
	14 x 1 x 3	
A-12" and 14" F-12" and 14"	14 x 3 x 5	Rec. Two Sides 8 x ¾
F-16", 18" 20", 24" & 30"	20 x 4 x 10	
	20 x 4 x 12	Rec. Two Sides 14 x ⅞
	20 x 6 x 12	
A-12" and 14" Table	14 x 3 x 5	Rec. Two Sides 8 x ¾
	14 x 3 x 5	

Hanchett Mfg. Co., Big Rapids, Michigan

Machine/Model	Wheel Size	Type
18" Chuck Planer Type	20 x 3 x 12 to 20 x 4 x 12	1

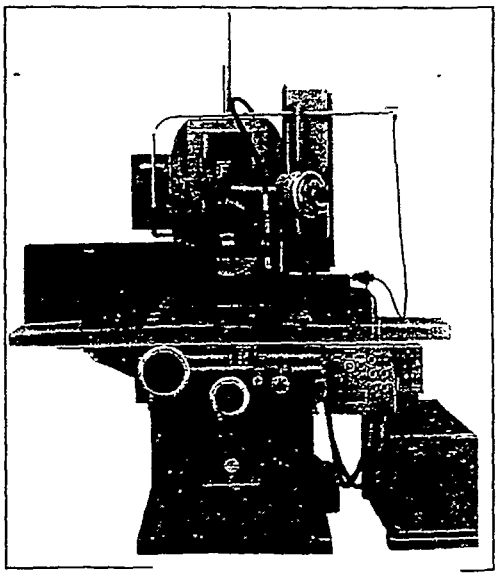
Heald Machine Co., Worcester, MA

Machine/Model	Wheel Size	Type
No. 20 and 22 8" Old Style	10 x 1 x 3½	
No. 20 and 22 12" Old Style	12 x 1 x 5	
No. 22 New Style 8" & 12"	12 x 1 x 5	1
No. 261 & 361	14 x 1 x 5	
No. 25A 8", 12" and 16" For Serial 14700 & Up Furnish 18" Dia.	16 x 2 x 8	
	18 x 2 x 8	Rec. Two Sides 10½ x ½
No. 25A 24" and 30"	18 x 2 x 8	7

The Hill Acme Co., Cleveland, Ohio

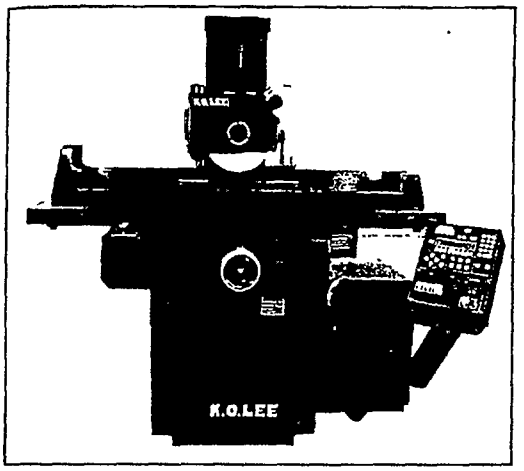
Machine/Model	Wheel Size	Type
Horizontal Spindle Reciprocating Table	20 x 2 x 10	1
	20 x 3 x 10	Rec. 1 Side 12¼ x 1
	20 x 4 x 10	Rec. 2 Sides 12¼ x 1
	20 x 5 x 10	Rec. 2 Sides 12¼ x 1¼
	20 x 6 x 10	Rec. 2 Sides 12¼ x 1½

Wheel Size 12 x 1 x 3. WA46-G12-VC: 9A461-H10-VA. This machine designed and built for ceramic grinding wheels. 3MSB541-H8-VSA



K.O. Lee Co., Aberdeen, S.D.

Machine/Model	Wheel Size	Type
S 600 Series S 700 Series	8 x 3/4 x 1 1/4	1



Above: Typical Reciprocating Surface Grinder
Wheel Size:
Wheel Grades

Hard Steel	Soft Steel
9A54-F6-VA	29A461-H10-VA
WA543-E10-V	LA463-G12-VC
3MSB601-D8-VSA	3MSB461-F10-VSA

Magerle (Switzerland)

Machine/Model	Wheel Size	Type
Reinforced Surface Grinder F10/12/15-V	300 MM x 100 MM x 127 MM	1
	400 MM x 100 MM x 127 MM	Various Recesses
Large Surface Grinder F100/120	400 MM x (50 to 90 MM x 127 MM	1
	500 MM x (50 to 90 MM x 203 MM	Various Recesses

Mattison Machine Works, Rockford, Illinois

Machine/Model	Wheel Size	Type
12" and 14" Old Style	14 x 3 x 4	Rec. 2/Sides 7 x 5/8
12" and 14" New Style	16 x 6 x 10	Rec. 1/Side 12 1/2 x 1 O/Side 12 1/2 x 2
16", 20" 24" Old Style	16 x 6 x 5	Rec. 1/Side 8 x 1 O/Side 8 x 2
	16 x 3 x 10	Rec. Two Sides 12 1/2 x 5/8
	16 x 6 x 10	Rec. 1/Side 12 1/2 x 1 O/Side 12 1/2 x 2
	20 x 2 x 10	
	20 x 3 x 10	1
	20 x 3 x 10	Rec. 1/Side 12 1/4 x 1/2 Rec. O/Side 12 1/4 x 1
	20 x 4 x 10	Rec. 1/Side 12 1/4 x 1
	22 x 3 x 10	Rec. 1/Side 12 1/4 x 1
	22 x 6 x 10	Rec. 1/Side 12 1/2 x 1 O/Side 12 1/2 x 2
16", 18", 20" 24" and 30" New Style	20 x 6 x 10	Rec. 1/Side 12 1/2 x 1 O/Side 12 1/2 x 2

Norton Co., Worcester, MA

Machine/Model	Wheel Size	Type
6" x 18" Horizontal Spindle Reciprocating	7 x 1/2 x 1 1/4 7 x 3/4 x 1 1/4 8 x 1/2 x 1 1/4 8 x 3/4 x 1 1/4	1
8" x 24" Horizontal Spindle Reciprocating	10 x 1 x 3	
10"	10 x 1 1/2 x 3	
10" for Die Grinding	20 x 1 1/2 x 3	
6" x 10" x 36" Old Style	10 x 3 x 3	Rec. Two Sides 5 1/2 x 3/4
12" x 36" S-1	14 x 1 x 5	1
15" x 15" Old Style	14 x 3 x 5	1
	14 x 4 x 5	Rec. 2/Sides 8 x 1/2
	14 x 5 x 5	Rec. 2/Sides 8 x 1
	14 x 6 x 5	
10 TS	12 x 3/4 x 3	1
6" S3	8 x 3/4 x 1 1/4	1
8 x 24 S3	10 x 1 x 3 or 12 x 1 x 3	1
S-1 12 x 48 14 x 36 14 x 48 16 x 36 16 x 48	14 x 1 x 5 or 14 x 2 x 5	1
Type N10 x 18 or 10 x 24	10 x 1 x 3 or 12 x 1 x 3	1

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Sundstrand Machine Tool Co., Rockford, Illinois (formerly Arter Grinding Machine Co.)

Machine/Model	Wheel Size	Type
Old Style 8" and 12"	12 x 1 x 5 12 x 1¼ x 5	
Old Style 16"	14 x 1 x 5 14 x 1¼ x 5 14 x 1½ x 5	
A-8" D12 A-12" D12 A-16"	12 x 1 x 8 14 x 1 x 8 14 x 1 x 8 14 x 1¼ x 8	1
B-20" B-24" B-30" B-40"	20 x 2 x 12 20 x 2 x 12 20 x 2 x 12 20 x 2 x 12	
C-8" C-12" C-16"	16 x 1½ x 8 16 x 1½ x 8 16 x 1½ x 8	
H Rotary H-16" H-20" H-24" H-30"	16 x 2 x 8	

Taft-Pierce Co., Woonsocket, R.I.

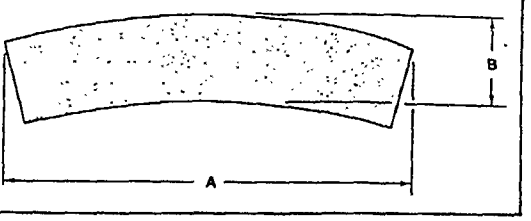
Machine/Model	Wheel Size	Type
No. 1 Precision Surface Gr. 6" Rotary	7 x ½ x 1¼	1

Thompson Grinder (Waterbury Farrel Div. of Textron, Cheshire, CT)

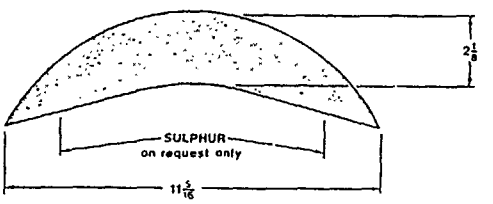
Machine/Model	Wheel Size	Type
F-6 F-6	12 x ½ x 1¼ 12 x ¾ x 3	1
B-1 B-2 B-6 B-8	12 x 1 x 5	1
B-3 B-4 B-8	12 x 1½ x 5	Rec. 1/Side 7¼ x ½
B-5 B-6A B-7 B-8A B-9 B-48 B-49 B-50 B-51 B-631	12 x 2 x 5 B-627	Rec. 2/Sides 7¼ x ½ B-628
B-10	12 x 1½ x 5	Rec. 1/Side 7¼ x ½
B-12	12 x 2 x 5	Rec. 2/Sides 7¼ x ½
C-12	12 x 3 x 5	Rec. 2/Sides 7¼ x ½
BB-12	20 x 11/2 x 8	Rec. 1/Side 7¼ x ½
BB-10 BB-12 BB-615 BB-616 BB-617 BB-633 BB-636 BB-629 BB-640 BB-641 BB-642 BB-661 BB-662	20 x 2 x 8	Rec. 2/Sides 11¼ x ½
BB-634 BB-635 BB-637 BB-638 BB-663 BB-664 C-12 C-14 C-16 C-18 C-20 C-24	20 x 3 x 8	Rec. 2/Sides 11¼ x ½

Segments

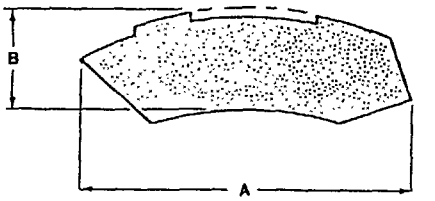
Crossley Segment Shape CR



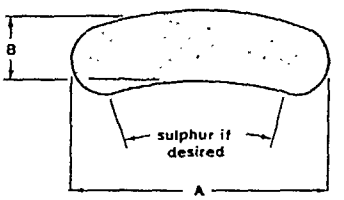
Abrasive Associates Segment Shape AA1



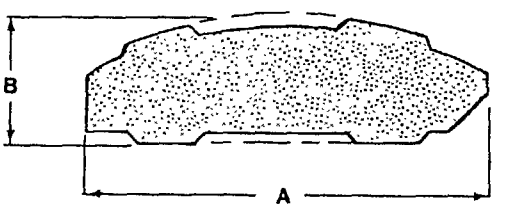
Hanchett Segment Shape HA



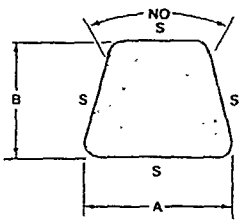
Blanchard Segment Shape BL



Hill Acme Segments

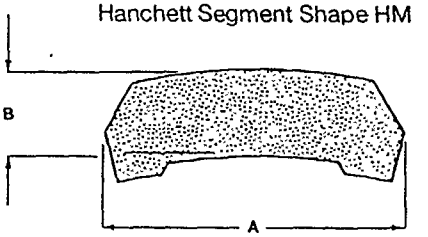


Blanchard Segment Shape BLA

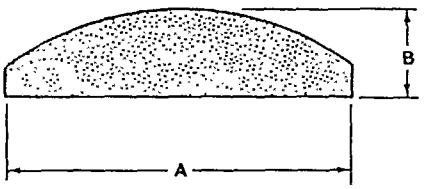


Areas marked with "S" will be sulphured if specified on order

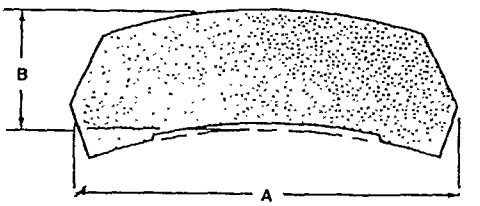
Hanchett Segment Shape HM



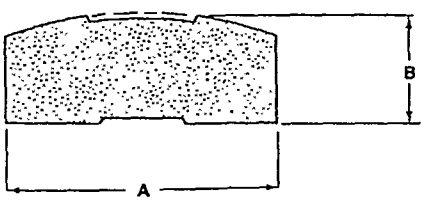
Cortland Segment Shape CD



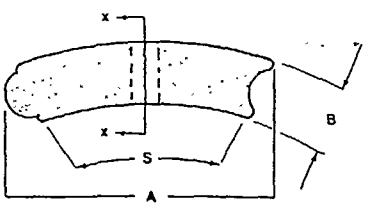
Norton Segment Shape NO



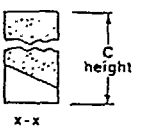
Segment Shape DIA



Sterling Shape STG Segments



Areas marked with "S" will be sulphured if specified on order



Segment Shape And Sizes

Style Number	Chuck Dia. in Inches	A-Length	Size in Inches B-Width	C-Height	Pieces Per Set
AA-1	All Dia.	11-5/16	2⅛	6	As ordered
BL-11	11	6¼	1¼	5	4
BL-18	18	7-1/16	1¾	6	6
BL-20	20	5-11/16	2	6	8
BL-27	27	7¾	2½	7	8
BL-32	32	9-9/16	2-11/16	7	8
BL-36	36	8-7/16	3	8	10
BL-42	42	10⅛	3	8	10
¢BLA-32	32	4½	3½	9	16
¢BLA-36	36	4½	3½	9	18
¢BLA-42	42	4½	3½	9	20
CD-6	6	3½	⅞	4	4
CD-8	8	4¾	1¼	4	4
CD-12	12	7½	1½	5	4
CD-14	14	8⅞	1¾	5	4
CD-16	16	10⅛	2	5	4
CD-18	18	11¼	2¼	5	4
*CD-18L	18	11¼	2¼	6	4
CD-20	20	8	1⅞	6	6
CD20A	20	10⅛	2	6	5
*CD20B	20	11¼	2¼	6	4
*CD22	22	11¼	2¼	6	5
*CD24A	24	11¼	2¼	6	5
*CD26	26	11¼	2¼	6	6
*CD27	27	11¼	2¼	6	6
*CD30A	30	11¼	2¼	6	7
CD32	32	8	1⅞	6	10
*CD32A	32	11¼	2¼	6	7
*CD36	36	11¼	2¼	6	8
*CD42	42	11¼	2¼	6	10
*CD44	44	11¼	2¼	6	10
*CD48	48	11¼	2¼	6	11
*CD54	54	11¼	2¼	6	12 or 13
*CD60	60	11¼	2¼	6	14
*CD120	120	11¼	2¼	6	30

* Identical shape (CD Universal)
¢ Identical BLA shapes
CD Universal segments are also available in a 3" thickness and 8" in length.
Possible combinations are:

Size	Designation (Example)
11¼ x 2¼ x 6	CD22[1]
11¼ x 3 x 6	CD22-3
11¼ x 2¼ x 8	CDH22
11¼ x 3 x 8	CDH22-3

[1]*Any style no. which uses the Universal segment can be substituted*

MIL 000190

Style Number	Chuck Dia. in Inches	Size in Inches A-Length	B-Width	C-Height	Pieces Per Set
CR-42	42	10 3/4	2 1/8	6 1/4	12
DIA-30	30	6 1/2	2	7 1/4	12
DIA-36	36	6 1/2	2	7 1/4	15
HA-16	16	5-5/16	1 1/4	6	8
HA-20	20	5-5/16	2	7	10
HA-24	24	5-3/16	2	7	12
HA-30	30	7-3/32	2	7	12
HA-36	36	7 7/8	2	7	12
HA-36A	36	8-9/32	3	7	12
HA-48	48	8-33/64	3	8	16
HA-44	44	8	3	7	15
HI-23	23	7 1/8	2	7 1/4	8
HI-26	26	7 1/8	2	7 1/4	9
HI-30	30	7 1/8	2	7 1/4	10
HI-32	32	7 1/8	2	7 1/4	1
HM-14	14	5 1/8	1 1/2	6	6
HM-18	18	5	1 1/2	6	8
HM-20	20	5-15/16	2	6	8
HM-22	22	6-11/16	2	6	8
HM-26	26	6 1/2	2	6	10
HM-32	32	6 3/4	2	7	12
NO-14	14	5	1 1/2	6	6
NO-18	18	5	1 1/2	6	8
NO-18A	18	5-9/16	2 1/4	6	8
NO-20	20	5	1 1/2	6	9
NO-22	22	5	1 1/2	6	10
NO-24	24	5	1 1/2	6	11
NO-26	26	5	1 1/2	6	12
NO-27	27	5	1 1/2	6	12
NO-32	32	5	1 1/2	6	14
NO-36	36	5	1 1/2	6	16
NO-42	42	5	1 1/2	6	20
STG-10	10	4-15/16	1	4	6
STG-12	12	5-15/16	1 1/4	5	6
STG-14	14	5-5/16	1 1/4	4	8
STG-14A	14	5-5/16	1 1/4	5	8
STG-16	16	6	1 1/4	4	8
STG-16A	16	6	1 1/4	5	8
STG-16B	16	6	1 1/4	6	8
STG-18	18	6-13/16	1 1/2	5	8
STG-18A	18	6-13/16	1 1/2	6	8
STG-18B	18	6-13/16	2	5	8
STG-18D	18	6 7/8	4	5	8
STG-20	20	6-13/16	1 1/2	5	9
STG-20A	20	6-13/16	2	5	9
STG-30	30	8	2	6	12

Test Data Sheet

Customer: _____

_____

_____

Observed By: _____

Coolant Used: _____

Table R.P.M.: _____

Test Series No.: _____ Date: _____

Machine Specifications

Make: _____ H.P. _____

Spindle R.P.M. _____ Table Size _____

Wheel/Segment (A) Size/Shape _____

(B) Grade _____

(C) Area (in.^{2}) _____

Table Load No.	Parts Per Table	Part Area (in.^{2})	Material Type	Feed Rate in./min.	Total Infeed (.001)	Motor Load % FL.	Grind Cycle Time	Metal in .000	Metal in.^{3}	Abrasive Loss	Abrasive Loss in.^{3}	G Ratio

Some Basic Formulae

Area of a rectangle	= Base x Height	A = BH
Area of a square	= Base^2	A = B^2
Area of a parallelogram	= Base x Height	A = BH
Area of a triangle	= 1/2 Base x Height	A = 1/2BH
Area of a trapezoid	= 1/2 Base + Base1 x Height	A = 1/2 (B+B1)H
Area of a circle	= 3.1416 x radius^2	A = πR^2
Circumference of a circle	= 3.1416 x diameter	C = πD

General Recommendations

Vertical Spindle Rotary Table

The large contact areas encountered in this type of grinding make the wheel or segment selection very critical. The general rule is to use a soft open specification on large work areas and to use harder specifications if work areas are decreased. We find a maximum efficient work area for general use on a 36" table to be about 450 square inches. However, workpiece dimensions, loading and handling time may dictate the use of larger or smaller work areas. Whenever possible, do not load the center of the table, but it is advantageous to pass the workpieces through the center of the wheel or segment assembly. Use relatively low table speeds when grinding large area parts in order to minimize heat generation.

Higher table speeds are recommended for small area parts to keep them from moving. High horsepower machines will usually require harder wheels and segments than those generally recommended.

To minimize heat distortion when grinding thin work, it may be necessary to add auxiliary coolant lines to blast coolant into the primary grinding zone.

You will note the specification change for large and small work areas. Likewise, we go softer for large segment areas in square inch per piece, such as for CD 18xT8, and harder for small segment areas, such as NO18. These specifications consider AA1 and CD18 segments as normal areas of contact.

GENERAL PURPOSE

NOTE:

A. To obtain segment volume (In.^{3})
   Segment Area x Segment Height

B. To obtain segment "usable volume" (In.^{3})
   Segment Height - Stub Height x Segment Area

C. To obtain *metal volume*, simply measure the area of one part then multiply by number of parts. Then multiply total area by amount of metal removed in decimals. This gives you cubic inches of metal.

D. To obtain *abrasive lost:*
   Find your segment area on the chart on page 24, and multiply by inches (in decimals) the abrasive lost during the grind, i.e., if you feed down .040" and remove .015 from the part, obviously you lost .025 from the segments.

E. Divide metal removed by abrasive lost and you have "G" ratio (cubic inches of steel removed by cubic inch of wheel).

1. **Type of Parts**
   A. Soft Parts - Boiler plates, blocks, gates, punch outs, misc.
   B. Hard Parts - Gears, dies, washers, piston rods, etc.
2. **Grading the Wheel**
   Horizontal Spindle Reciprocating

   The main variable in surface grinding is the hardness of the part. This will necessitate a change in wheel grading; however, most soft parts can be roughed and finished with the same wheel and the same rule applies to hard parts.

	Soft	Hard
Stock	.025 - .040	.004 - .010
RMS	25 - 40	12 - 17
Grinding Rate	Medium	Slow
GR Wheel	2A46-I6-VL	97A701-J4-VFM

This information pertains mainly to horizontal spindle reciprocating surface grinding.

3. **Grading the Wheel**
   Vertical Spindle Rotating Table

   This is another popular type of surface grinding. This requires segments largely and Type 2 cylinder wheels.

   A. Soft Material = Parts are usually large — intermittent, and stock removal is high. A good segment grade is 97A241-G10-VL, VA, V, VC.
   B. Hard Material = Stock removal quite less. Grinding time is longer accordingly, and the RMS is improved by finer grit sizes and spark out time. A good grade for hard material is 97A461-F10-VL, VA, V, V or WA461-D12-VC.
4. **Trouble Shooting**
   A. Horizontal Spindle
      1. Chatter - Wheel too hard - Wheel out of balance - Setup not rigid.
      2. Burn - Wheel too hard and/or too fine - Poor coolant application - Grinding rate too fast.
      3. RMS too rough - Wheel too soft - Grinding rate too fast.
   B. Vertical Spindle (Segments)
      1. Chatter - Segments too hard - Interrupted cut and setup not rigid.
      2. Burn - Segments too hard - Grinding rate too slow - Poor coolant application.
      3. RMS too rough - Segments too soft or grinding rate too fast.

Producing flat surfaces with surface grinding machines is extremely important. No other method can produce an accurate flat surface as quickly and economically, and at the same time handle a variety of work ranging from small instrument parts to large castings. From flat locating surfaces subsequent machining operations can be performed accurately. Surface grinding also encompasses contoured surfaces on soft and hard materials.

Surface grinding wheels must be cool cutting to avoid burning and warping parts. To minimize tedious wheel dressing and wheel changing, surface grinding wheels must be as close to self-dressing as possible and each wheel must be able to grind a wide variety of jobs. CINCINNATI Surface Grinding Wheels are quick-cutting, cool-grinding, versatile, and virtually self-dressing when correctly graded. Correct grading to your surface grinding application is easy with the help of your Cincinnati Milacron Marketing Company representative.

Once on grade, successive wheels that you order will give you the same grinding action. Through our manufacturing system featuring unvarying, in process quality control, duplication of the original wheel is assured with each reorder. On grade with a CINCINNATI Surface Grinding Wheel means that all future wheels will act and grind alike.

Most horizontal spindle surface grinding requires straight or recessed wheels. Vertical spindle surface grinding requires (depending on the grinder) segments, cup wheels and cylinder wheels. Cincinnati has a wide variety of surface grinding wheels to meet your needs. We can also recommend a CIMCOOL grinding fluid featuring rapid grit setting and exceptional cleanliness.

Rotary surface grinding was the original abrasive machining (fast, heavy stock removal by grinding competition with other metal removal processes), and the only significant one, until 1963, when the bridge-type centerless grinder was introduced. Now high-speed, high-efficiency center-type grinders have joined the abrasive machining parade too, but surface grinders are still a big part of it.

Some big surface grinding machines, such as one with a 250 h.p. head, a 48" grinding wheel in the form of 11 segments held in a chuck, and a 96 work-holding magnetic chuck cost considerably more to operate than the smaller machines. But they can often beat planers and milling machines on overall cost in spite of the lower cost per machine-hour operated of these machines, because they frequently remove metal at least 41/2 times faster. They can hold tolerances more easily and get a better finish; finishes of 63 rms are routine. Ease of workpiece clamping (magnetic chucks) is another advantage rotary surface grinders have over planers and milling machines in operations that can be done by abrasive machining.

Surface grinders give minimum distortion, no induced stress, a burr free operation and freedom from complex fixtures.

Whether your surface grinding is complex or a simple toolroom operation, you can count on us. We'll use our experience in making and servicing grinding machines. CINCINNATI MILACRON Grinding Wheels and CIMCOOL Cutting Fluids, plus a spirit of innovation, to help you make the job run smoothly and profitably.

Height And Area Per Set

Seg. Shape	Pieces Per Set	Hgt.	Area Per Set (In.²)
AA-1	As Req.	6"	20.0
AA-2	As Req.	5½"	
BL-11	4	5"	31.2
BL-18	6	6"	71.7
BL-20	8	6"	84.8
BL-27	8	7"	145.8
BL-32	8	7"	217.7
BL-36	10	8"	235.7
BL-42	10	8"	287.1
BLA-27	8	7"	145.8
BLA-32	16	9"	221.7
BLA-36	18	9"	249.4
BLA-42	20	9"	277.1
CD-6	4	4"	9.7
CD-8	4	4"	18.9
CD-12	4	5"	33.3
CD-14	4	5"	44.3
CD-16	4	5"	58.4
CD-18	4	5"	74.1
CD-18L	4	6"	74.5
CD-20	6	6"	76.8
CD-20A	5	6"	72.7
CD-22	5	5"	92.6
CD-22I	5	6"	93.1
CD-24	8	7"	89.6
CD-26	6	6"	111.7
CD-27	6	6"	111.7
CD-30	10	6"	130.7
CD-30A	7	6"	130.3
CD-32	10	6"	128.0
CD-32A	7	6"	130.3
CD-36	8	6"	148.9
CD-42	10	6"	186.2
CD-48	11	6"	204.8
CR-42	12	6¼"	263.6
DIA-30	12	7¼"	143.5
DIA-36	15	7¼"	181.7
GO-12	8	3¾"	
GO-16	10	7"	
HA-16	8	6"	45.1
HA-20	10	7"	78.9
HA-24	12	7"	102.1
HA-30	12	7"	137.8
HA-36	12	7"	166.0
HA-36A	12	7"	242.4
HA-48	16	7"	336.6
HI-23	8	7¼"	98.7
HI-26	9	7¼"	111.0
HI-30	10	7¼"	123.3
HI-32	11	7¼"	135.6
HM-14	6	6"	43.4
HM-18	8	6"	55.2
HM-20	8	6"	87.2
HM-22	8	6"	101.2
HM-26	10	6"	217.2
HM-32	12	7"	151.8
NO-14	6	6"	41.4
NO-18	8	6"	55.2
NO-18A	8	6"	90.0
NO-20	9	6"	62.1
NO-22	10	6"	69.0
NO-26	12	6"	82.8
NO-32	14	6"	96.6
NO-36	16	6"	110.4
PE-11	6	4"	
PE-12	6	6"	
PE-12A	6	6"	
PE-18	8	5"	
PE-22	10	6"	
RO-12	7	4"	
RO-14	8	4"	
RO-16	8	4"	
RO-20	10	4½"	
RO-20	8	4½"	
STG-10	6	4"	27.2
STG-12	6	5"	41.3
STG-14	8	4"	50.0
STG-14A	8	5"	48.0
STG-16	8	4"	56.4
STG-16A	8	5"	56.9
STG-16B	8	6"	56.9
STG-18	8	5"	75.7
STG-18A	8	6"	75.7

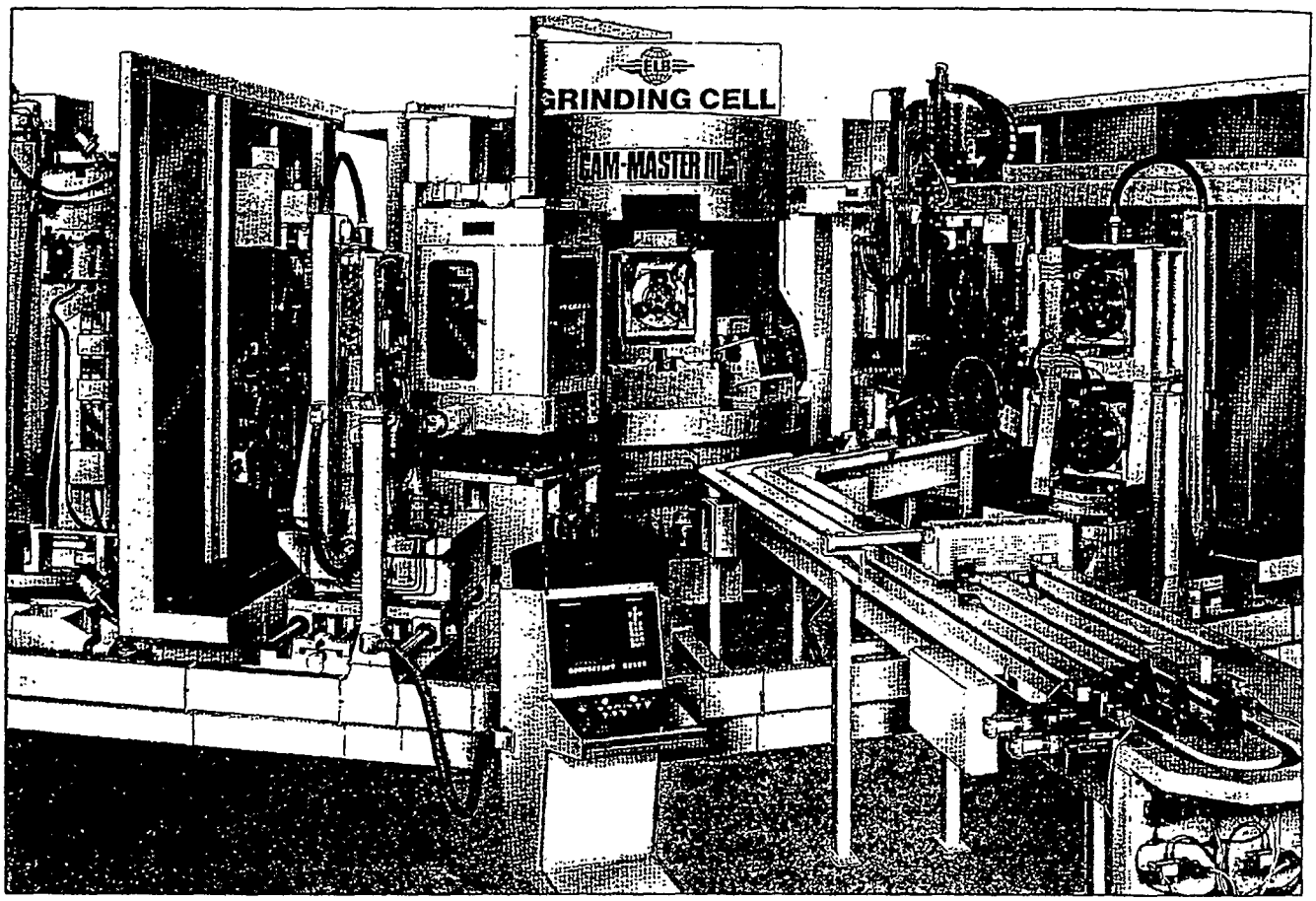
Test Form And Procedure For Computing "G" Ratio.

See Page 10-18 and 10-19

Seg. Shape	Pieces Per Set	Hgt.	Area Per Set (In.²)
STG-18B	8	5"	98.1
STG-18D	8	5"	173.0
*STG-GAP	8	5"	67.8
STG-20	9	5"	84.7
STG-20A	9	5"	110.3
STG-20B	9	6"	109.7
STG-20C	9	6"	85.2

Special STG-18 "GAP Type"

11 Creepfeed Grinding



ELB's Cam-Master Machine features 5 grinding heads with automatic wheel change.
Typical wheel grade for turbine blades would be WA603-D15-VF or 9A601-E12-VCR. A typical wheel size is 24 x 2 x 8.

Starting Grade Recommendations

	Straight Grind	Form
Soft Steel	LA461-F15-VC4	LA601-F12-VF4
Hard Steel	WA541-D12-VF4	WA601-E12-VF4
Inconel	WA601-E12-VF4	WA603-D12-VF4
Alloys	WA531-D15-VF4	WA543-D12-VF4
Stainless	WA541-E15-VF4	WA601-E12-VF4

MSB is applicable for most creepfeed applications. Call Cincinnati's Abrasive Engineering Group for MSB grade recommendations.

MIL 000196

Creepfeed surface grinding is like formed milling except the wheel, instead of the cutter, removes the stock in one pass at a slow table speed. Creepfeed gives high accuracy, high production and good finish, and works well on many difficult-to-cut metals. The picture shows sample parts which have been creepfeed ground. Parts vary from the size of a needle to 10" wide forms 3" deep. The method lends itself to CNC tapes and can have different axes on both the work and the grinding spindle.

Will any machine do the job?

Creepfeed machines are specially made for high velocity of fluid flow, rigidity of table, grinding spindle and dresser mechanism. They have high horsepower, hold a constant SFPM as the wheel wears down, and have a slow table speed 2 IPM to 80 IPM. The dress mechanism varies with the production needed. Highest production is with diamond rolls and continuous dress (CD measured in millionths infeed per revolution of the grinding wheel), or with intermittent dress. Shorter run jobs can use crush dressing, or single point dressing.

What kind of parts are creepfeed ground?

Very small parts tend to use finer grain grinding wheels and high wheel speeds, like 8500 SFPM. This reduces pressure and permits the fluid, at high psi (70 to 200 psi), to penetrate the arc of contact. Larger parts with deeper cuts can run at wheel speeds of 3000 SFPM to 6500 SFPM to reduce total heat. 6000 SFPM is generally the most efficient speed. The type of fluid, volume, velocity and direction are very critical in creepfeed grinding.

How is creepfeed done?

Most creepfeed is done in the down cut or climb mode, to put pressure on the table and to make fixturing easier. In down-cut, the wheel and table are going in the same direction at the point of contact. But on large cuts or where burn is critical, up-cut with the table going opposite to the wheel at contact brings heat up and away from the work surface, allowing higher table speeds. The variables in creepfeed grinding are: depth of cut, table speed in IPM, wheel speed in SFPM, type of dress, amount of dress, ratio roll to wheel in SFPM (.8 ratio opens the wheel to cut aggressively. A ratio of 1 would be a crush dress). The grinding wheels are very soft in grade, high in rupture strength and extremely open in structure. Sample wheel specifications are given above. These vary with the method of dressing and work radii needed.

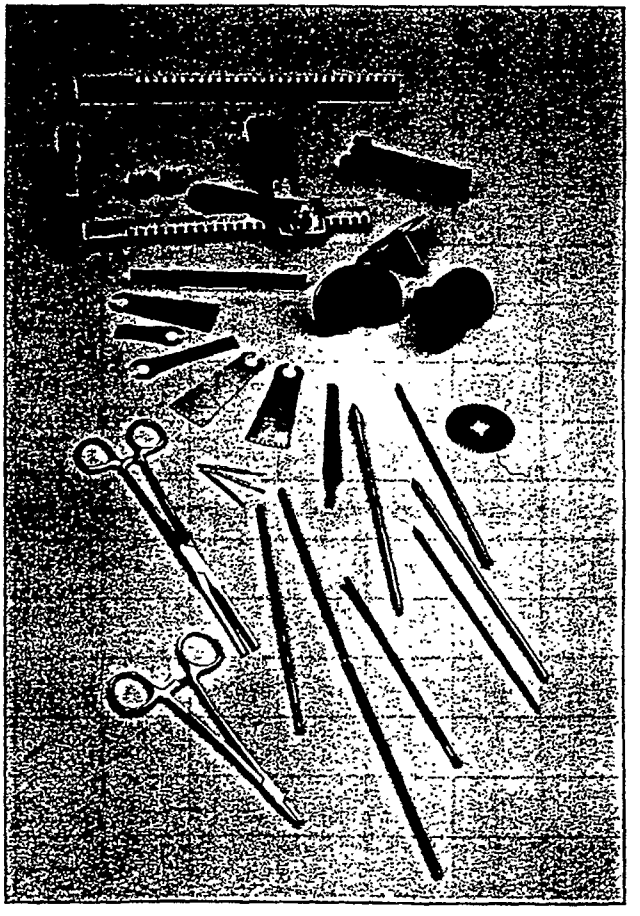
What fluids are used for creepfeed grinding?

Water soluble oil such as CIMPERIAL® 1011 metalworking fluid gives lubricity to the cut and helps the G ratio while removing heat. This is especially helpful in large cuts where huge volumes of chips, like steel wool, are removed with special filters.

Variable and short run jobs often run with clear solutions such as CIMTECH® 500 metalworking fluid for easy in handling.

Sample Wheel Specifications

Aircraft Blade (Inconel)	WA603-E12-VF
Aircraft Blade (Stainless)	WA543-D15-VF
Aircraft Blade (Inconel Root)	WA603-C15-VF
Steel Forgings	WA702-F15-VF



MIL 000197

Creep Feed Data Sheet

CUSTOMER

ADDRESS

CITY STATE ZIP

CREEP FEED

WHEEL SIZE MACHINE H P SPECIFICATION

MATERIAL HARDNESS SIZE COOLANT TYPE

TYPE DRESSER FINISH RADIUS

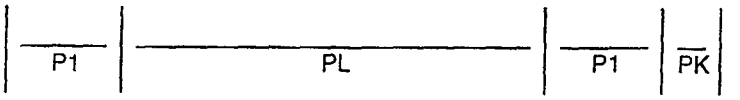
Wheel Dia.	Cut Width	Cut Length	Depth of Cut	Ratio SFPM Roll/Whl	Table Speed I.P.M	Wheel SFPM	Roll Infeed Mil/Rev	Dress Amount*	Time Grd.	Cut Up or Down	Amps or % Load	Comments

*If intermittent dress, amount of dress
If C.D. (continuous dress) = RPM x time x roll infeed

Abrasive cost in³ S.R.	Machine cost in³ S.R.	Total cost in³ S.R.

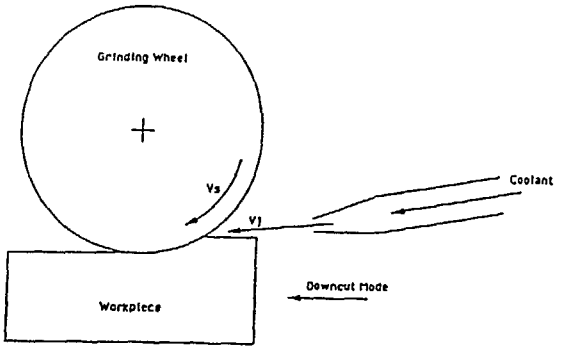
MIL 000198

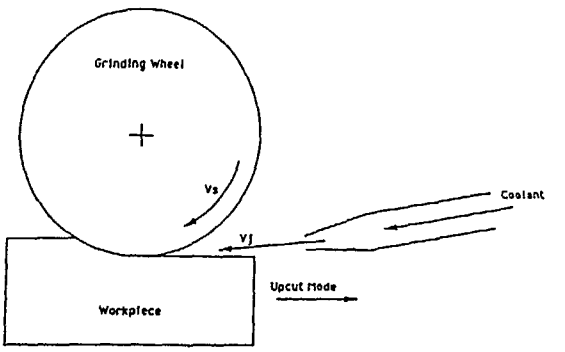
R = Grinding Wheel Radius
P1 = $(R^2 - (R - (PG + PS^2)))^3$
PL = Part Length
PK = Part Over Travel Typical .04
PG = Depth of Cut
PS = Stock Remaining Over Finish



PART
LENGTH

Dress Length = (2xP1) + PL + PK





11

Creep Feed Grinding Wheels
VCR Product Availability

	Aluminum Oxide	Silicon Carbide
Abrasive Types	9A, 4A, 12A, 29A, 97A, 2A	5C, 6C, 7C
Abrasive Sizes	*46, 54, 60, 70, 80, 90, 100, 120	*46, 54, 60, 70, 80, 90, 100, 120
Grades	*C, D, E, F, G	C, D, E, F,G
Structures	*10, 12, 14, 16	*10, 12, 14
Wheel Size	6" through 30" O.D.	3/4" through 6" thick

*Exception: C grade is not available in 46 grit, 10 structure.
C grade is available in 46 grit, 12, 14 and 16 structures.

*Standard Maximum Wheel Speeds — SFPM

Wheel Type	Grit Size and Grade	
	36 and Finer	
	***C-D-E	F, G
6	4500	5000
2	5000	5500
Other	***6500	6500

**See special speed chart for overspeed applications.
***Maximum operating speed for a 46 grit, C12 Specification is 6000 SFPM.

MIL 000199

Deep Cut and Creep Feed Grinding

On the American metalworking scene creep feed grinding is an exciting development that is changing the industry's views about grinding productivity. Most successful creep feed operations are being done with products that have been produced expressly for creep feed applications.

Most of the development work for creep feed grinding has been conducted in Europe, although the first actual creep grinding was done in the States. One of the probably causes for this lies within the name itself. Creep, to most people, means slow and slow is not a popular word around most of our high-production grinding shops. A word which has and is gaining popularity is productivity. When American manufacturers took an indepth look at creep grinding they were surprised to learn that although the machine tables were moving slow, the productivity was greatly increased. They were also surprised to learn that the parts were burn free and required no deburring operation after the grind. This first caught the eye of the aircraft industry whose part specifications required perfect parts with no burn, burr or heat distortion. Thus, the early stages of creep feed grinding in the U.S. were done in aircraft plants.

What exactly is creep feed grinding, and how does it work? Creep feed grinding is a milling operation performed with an abrasive wheel. Different from customary reciprocating grinding, creep feed is a grinding technique capable of removing metal from a solid workpiece — up to 1" of stock removal in a single pass! Because creep feed grinding demands the use of a soft, open wheel, it is especially appropriate for applications where burr and burn-free parts are absolutely vital, as they are in the electronics, ceramics and aerospace industries.

Creep feed grinding is capable of reducing as much as 50% of your machine cycle time since it eliminates the need for rough machining, milling, de-burring and other finishing steps; and this lowers material handling as well as inventory costs. Furthermore, creep feed grinding minimizes heat distortion and cracks thereby curtailing — even eliminating re-work costs! Still, another advantage to creep feed grinding is that the operator no longer needs to (repeatedly) sharpen a mill cutter; so, time and money are also saved.

Not only will creep feed save money and time, it will improve production, efficiency and yield a better finished product at a lower cost per piece. This all adds up to what it's all about — PRODUCTIVITY!

Even with all of its' advantages creep feed grinding has been slow to be recognized in the metalworking industry — but why? To answer this question let's take a brief look at its origin. From its' inception, in America's 1940s, creep feed grinding quickly acquired an unfair reputation simply because its' very name implied that the process was too slow, especially for our nation's production demands. A table speed of 1 to 2 inches per minute failed to impress a very time conscious industry like ours. Another reason why creep feed grinding failed to make a positive impression was that a few industries, however remotely interested in it, attempted to perform various creep feed operations on their existing equipment and failed because their machines were not specifically designed for the creep feed application.

Successful creep feed grinding essentially requires three things:

1. A creep feed grinder
2. The correct wheel
3. The correct metalworking fluid

Once you have obtained the proper creep feed grinder to suit your needs, you will need the proper grinding wheels and metalworking fluids to make your creep operation a great success!

Creep feed grinders are unique when compared with conventional grinders in that they have:

— Higher horsepower motors
— Larger fluid tanks with cyclone filters and pumps capable of adequately flooding the workpiece with high velocity fluid.
— A rigid table with a rigid feed control

To properly and effectively creep feed grind the following rules must always apply:

Rule #1: The wheel, part and fluid should travel in the same direction (or downcut).

Rule #2: Both the sharp abrasive wheel (featuring a very open structure) and the metalworking fluid should travel up to 73 MPH (This is 6500 surface feet per minute).

Rule #3: The key to success with creep feed grinding is high velocity fluid 100-200 gallons of coolant per minute is required, depending upon the size of the job and the wheel.

Rule #4: An adequate fluid system pipe must be used. one that is at least 1½" coming to a constantly reducing nozzle (to increase pounds per square inch), thereby maintaining gallons per minute (G.P.M.'s).

Operators must be aware that burr and burned parts are a result of an inadequately applied or misapplied fluid.

Creep Feed grinding should be accomplished in the "down grind" or "climb-grind" mode. Climb-grinding automatically eliminates the burr. Chips are not formed, pushed, or rolled to the edges, but pulled through the cut and devoured or reduced to a fine wiry swarf.

Feed rates are determined by the depth of the cut, width of the cut, hardness of the material, and, of course, the difficulty of the job. The deeper the cut, the slower the procedure. In some applications where burn is persistent, the up-grind mode may be helpful.

At this point a word about creep feed tables is appropriate. Small hydraulic cylinders do not provide rigidity, power or a stable force, elements vital to creep feed applications. Preferred creep feed table drives feature a heavy duty ball nut feed screw and heavy duty motors to facilitate the positive feed control required for its application.

Grinding wheels are specifically designed to meet creep feed grinding's harsh demands. They key to their success lies in the term "S.O.S." — meaning soft, open and sharp. These wheels are composed of sharp aluminum oxide or tough silicon carbide abrasive. Creep feed wheels are produced by a process that results in a product that is extremely open in structure. There are some very good reasons for this: first, the open structure provides a place for the chip to go until it can be thrown out. Second, it facilitates the transportation of the metalworking fluid through the cut. Third, it lowers unit pressure and reduces the risk of burning.

These grinding wheels feature a soft grade which permits the sharp grains to do their job in an effective manner without damaging the part. As pressure increases the wheel simply fractures before part damage can occur. The result: no scrap, no heat and no distortion.

Producing burr and burn-free parts, when creep feed grinding, requires the application of the proper metalworking fluid. There is no better fluid to use than a premium soluble oil with EP additives. These fluids at 20:1 and 30:1 ratios permit you to creep feed grind on ferrous materials quickly, accurately and economically.

It is important to point out that, because of its slower speeds and deeper cuts, creep feed grinding requires a high gallon per minute (G.P.M.) fluid system with piping arranged in such a way as to increase pressure as the fluid nears the wheel. The fluid nozzle and its placement are also critical, most jobs require a custom designed nozzle to fit the shape of the part to be ground.

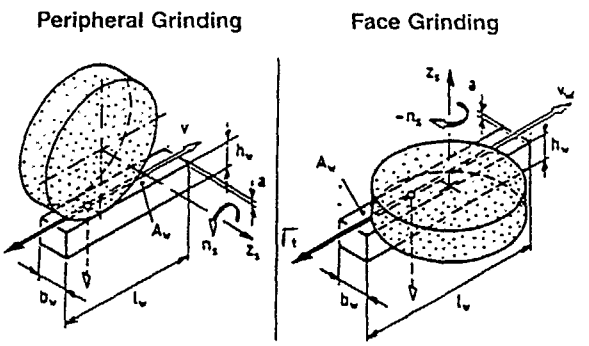
To eliminate any chance of burning, the fluid must be applied in the same direction that the part is traveling, pulled into and through the cut by the open-structured creep feed grinding wheel. Most creep feed grinding technical specialists will be happy to show you how to set up your creep feed grinding system.

Finally, you might be interested in knowing some of the manufacturers of quality creep feed grinders:

- ABA
- Excello
- ELB
- Gallmeyer & Livingston
- Hauni-Blohm
- Jung
- Mattison
- Magerle
- Niagara

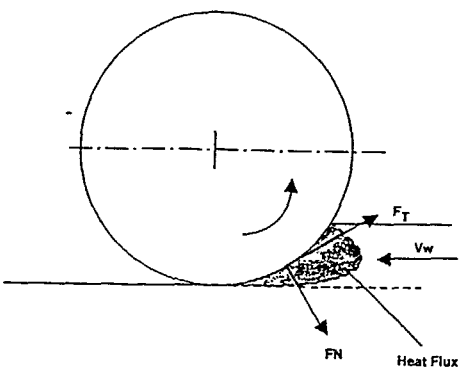
Grinding of Flat Surfaces Surface Grinding

- In peripheral surface grinding, the wheel axis of rotation lies parallel to the surface being ground.
- In face surface grinding, the wheel axis of rotation is perpendicular to the surface being ground.



Comparison of peripheral surface grinding and face surface grinding.

Up Grinding



- Less sensitive for burn
- Rougher finish (less rubbing)
- Increased Fn

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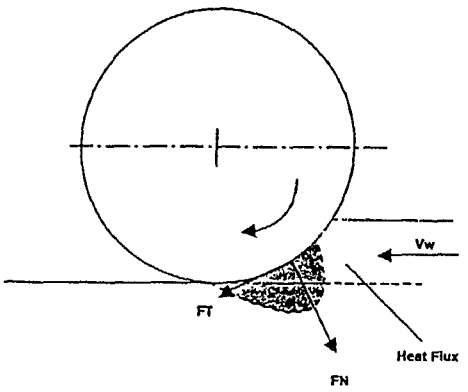
Down Grinding



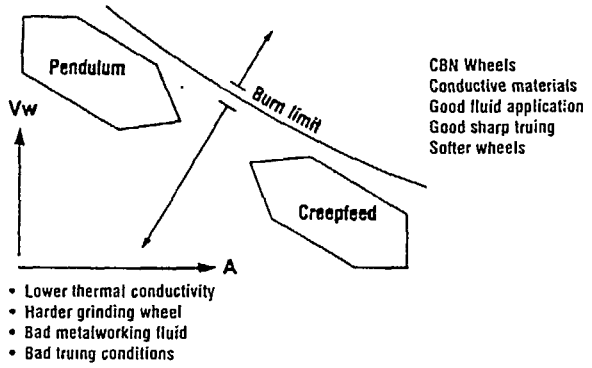
- More rigid
- Less burr
- More apt to burn
- Slightly better finish

Thermal Damage Constraint

Thermal damage constraint depends on:

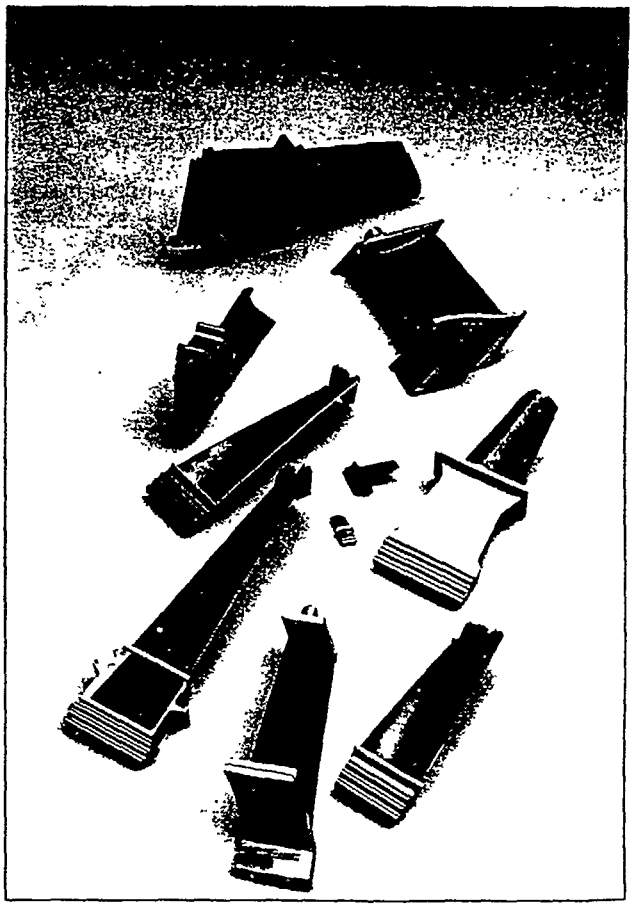
- Depth of cut and creepfeed rate
- Thermal conductivity of material
- Grinding wheel grading
- Truing technology
- Metalworking fluid and application
- For a given set of conditions it is essential to generate the thermal constraint diagram which defines the areas of non-thermal and thermal damage.

Creepfeed Grinding Thermal Damage



- Variables effecting thermal damage constraint

- Heat flow and thermal conductivity are important. On super alloys (low thermal conductivity) CBN wheels are conducting heat widening the constraint.
- Selection of table feed V_w and depth of cut is important and critical.
- Select wheel grades soft to avoid constraint for thermals.



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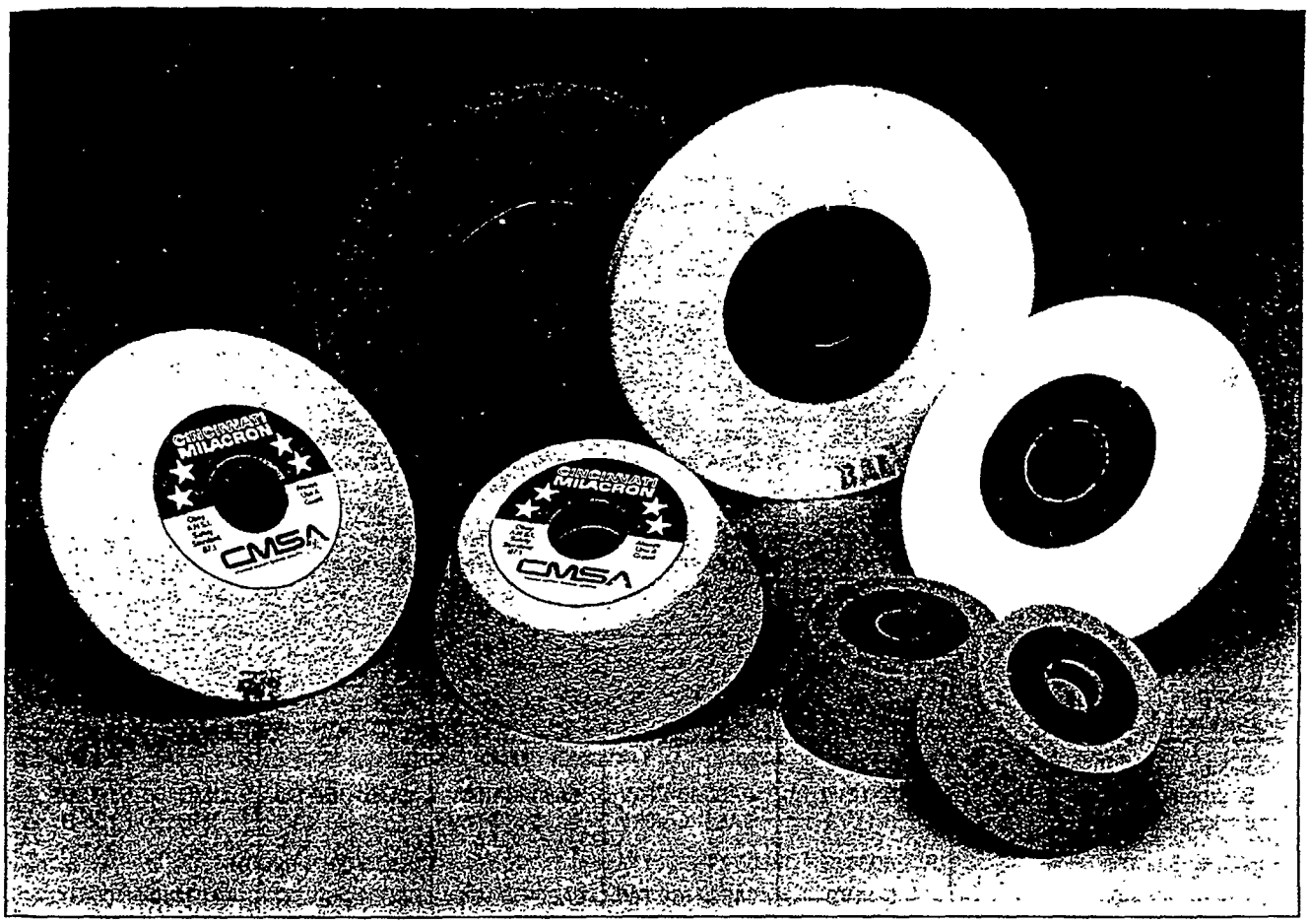
12 Tool Room Grinding



NOTE: Always consult the Cimform Grinding Wheel Stock Catalog for wheels in these size and grade families. Always try to utilize wheels which are in stock and encourage the customer to order quantities instead of one or two pieces.

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Recommended Starting Grades For Toolroom Grinding

Job	Wheel Type	H.S. Steel and Alloys	Carbon Tool Steel	Carbide (Green Grit)	Carbide (Diamond)
Hobs					
Tool & Cutter	12	9A60-H6-VRW	9A60-H6-VRW	5C60-J6-VSC	
Milling Cutters					
Tool & Cutter Gr.					
Face Mill & Side Mill	1-1A1-6A9	9146-I6-VRW	9A46-I6-VFW	5C60-J6-VSC	CMD120-P100-BY 1/8
End Mills	11-11V9	9A60-H6-VRW	9A60-H6-VRW	5C60-J6-VSC	CMD120-P100-BY 1/8
Formed Cutters	12-12A2	9A60-H6-VRW	9A60-H6-VRW	5C60-J6-VSC	CMD150-P100-BY 1/8
Shell End Mills (Large)	6-11V9	9A46-H6-VRW	9A46-H6-VRW	5C60-J6-VSC	CMD120-N100-BY 1/8
Shell End Mills (Small)	1-11V9	9A60-H6-VRW	9A60-H6-VRW	5C60-J6-VSC	CMD120-P100-BY 1/8
Side Mills (Small)	1-6-11V9	9A60-H6-VRW	9A60-H6-VRW	5C60-J6-VSC	CMD120-P100-BY 1/8
Lathe & Planer Tools					
Tool & Cutter Gr.					
Large Tools	6-11V9	9146-H6-VRW	9A46-H6-VRW	5C60-J6-VSC	CMD150-R100-BY 1/4
Small Tools	6-11V9	9A60-H6-VRW	9160-H6-VRW	5C80-J6-VSC	CMD220-R100-BY 1/8
Chip Breaker	1A1				CMD120-P100-BY 1/8
Reamers					
Cylindrical Gr.	1-1A1	9A60-J6-VRW	9A60-J6-VRW	5C80-I6-VSC	CMD220-N100-BY 1/8
Backing Off	1-6-11V9	9146-I6-VRW	9A46-I6-VRW	5C60-I6-VSC	CMD220-N100-BY 1/8
Taps					
Sharpening (Grind Chamfer)	1	9A60-I6-VRW	9A60-I6-VRW		
Squaring End	1	9A60-I6-VRW	9A60-I6-VRW		
Touch Up Flutes	1	9A60-H6-VRW	9A60-H6-VRW		
Broaches (Round, Spline, Etc.)					
Cylindrical (Wet)	1	9A80-J6-VRW	9A80-J6-VRW		
Sharpen	6-12	9A60-H6-VRW	9A60-H6-VRW		
Backing Off	6-11	9A60-I6-VRW	9A60-I6-VRW		
Broaches (Flat & Keyway)					
Sharpening	12-12V9	9A80-I6-VRW	9A80-I6-VRW	5C60-J6-VSC	CMD150-N100-BY 1/8
Backing Off	6-11V9	9A60-I6-VRW	9A60-I6-VRW	5C60-J6-VSC	CMD150-P100-BY 1/8
Boring Tools					
Tool & Cutter Gr.	6-11V9	9A60-H6-VRW	9A60-H6-VRW	5C60-J6-VSC	MD150-N100-BY 1/8
Counterbore & Spot Facers					
Small	1-11V9	9A60-I6-VRW	9A60-I6-VRW	5C60-J6-VSC	MD150-N100-BY 1/8
Large	1-11V9	9A46-H6-VRW	9A46-H6-VRW	5C60-J6-VSC	MD150-N100-BY 1/8
Drills — Sharpening					
Off Hand - Under 1/4" Dia.	1	9A80-H6-VRW	9A80-H6-VRW		
Off Hand - 1/4" to 1" Dia.	1	9A60-J6-VRW	9A60-J6-VRW		
Off Hand - Over 1" Dia.	1	9A46-J6-VRW	9A46-J6-VRW		
Drills (Machining Sharpening)					
Under 1/4" Dia.	6A2H-P.M.	9A80-H6-VRW	9A80-J6-VRW		CMD180-R100-BY 1/8
1/4" to 1" Dia.	6A2H-P.M.	9A60-J6-VRW	9A60-J6-VRW		CMD150-P100-BY 1/8
Over 1" Dia.	6A2H-P.M.	9A46-J6-VRW	9A46-J6-VRW		CMD120-N100-BY 1/8
Point Thinning	1	9A80-K6-VRW	9A80-K6-VRW		

To use VFM go 1 grade higher.
Use VSA on burn sensitive material.
Use 3MSB for general purpose tool steel, wet.
If grind is dry, use 5MSB.

Toolmaster®: Toolmaster wheels are available in both diamond and CBN. Most common sizes are available from stock, ready for immediate delivery.

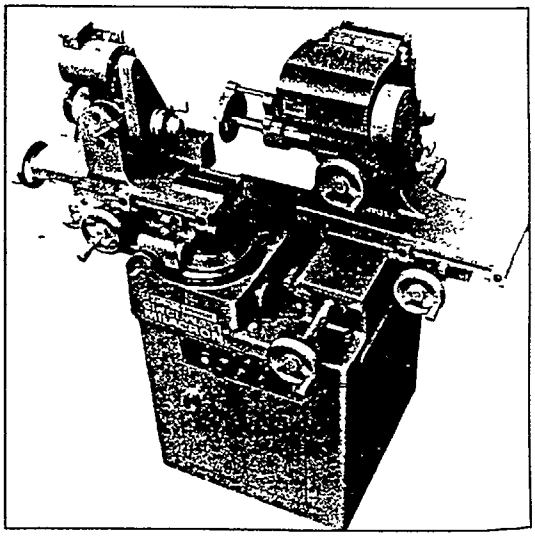
OD x THK x ID	GRADE	TYPE	PROD CODE	MOS	UPC CODE	APPLICATION
3¾ x 1½ x 1¼ 4064-D	BN150-W-BBL-1/16	11V9	6017VH1	9669	662506-10188	Tool Steel-Med. Finish
	BN100-W-BBL-1/8	11V9	607211	9669	662506-10184	Tool Steel-Roughing
	BN150-W-BBL-1/8	11V9	6017K1	9669	662506-10189	Tool Steel-Med. Finish
	NCD150-R100-BDL-1/16	11V9	6017G1	9669	662506-10150	Non-Ferrous Med. Finish
	NCD100-R100-BDL-1/8	11V9	608281	9669	662506-10143	Non-Ferrous Roughing
	NCD150-P100-BDL-1/8	11V9	611851	9669	662506-10147	Tool Steel-Med. Finish
	NCD150-R100-BDL-1/8	11V9	6017J1	9669	662056-10151	Non-Ferrous Med. Finish
4 x 0.032 x ¾	BN100-W-BBL-1/8	1A1R	8137A1	9072	662506-84830	Ferrous Cut-Off
4 x 0.032 x ¾	NCD100-R100-BDL-1/8	1A1R	8137D1	9072	662506-84831	Non-Ferrous Cut-Off
4 x 0.032 x 1¼	BN100-W-BBL-1/8	1A1R	8137E1	9072	662506-84832	Ferrous Cut-Off
4 x 0.032 x 1¼	NCD100-R100-BDL-1/8	1A1R	8137F1	9072	662506-84833	Non-Ferrous Cut-Off
5 x 1¾ x 1¼ 4065-D	BN150-T-BBL-1/8	11V9	6194X1	7257	662506-12345	Tool Steel-Med. Finish
	BN150-W-BBL-1/8	11V9	6017P1	7257	662506-12346	Tool Steel-Med. Finish
	NCD150-R100-BDL-1/16	11V9	6017L1	7257	662506-12327	Non-Ferrous Med. Finish
	NCD150-R100-BDL-1/8	11V9	6017M1	7257	662506-12328	Non-Ferrous Med. Finish
	NCD150-R75-BDL-1/8	11V9	6258T1	7257	662506-12326	Non-Ferrous Med. Finish
6 x 0.032 x 1¼	BN100-W-BBL-1/8	1A1R	8137G1	6048	662506-84834	Ferrous Cut-Off
6 x 0.032 x 1¼	NCD100-R100-BDL-1/8	1A1R	8137H1	6048	662506-84835	Non-Ferrous Cut-Off
6 x 0.062 x 1¼	BN100-W-BBL-1/8	1A1R	8137J1	6048	662506-84836	Ferrous Cut-Off
6 x 0.062 x 1¼	NCD100-R100-BDL-1/8	1A1R	8137K1	6048	662506-84837	Non-Ferrous Cut-Off
6 x ⅛ x 1¼	NCD150-R100-BDL-1/8	1A1	6014D1	6048	662506-12881	Non-Ferrous Med. Finish
6 x ¼ x 1¼	BN150-W-BBL-1/8	1A1	601781	6048	662506-13091	Tool Steel-Med. Finish
	NCD150-P100-BDL-1/8	1A1	601721	6048	662506-13080	Non-Ferrous Med. Finish
	NCD150-R100-BDL-1/8	1A1	6128D1	6048	662506-13081	Non-Ferrous Med. Finish
	NCD220-R75-BDL-1/8	1A1	6101D1	6048	662506-13082	Non-Ferrous Fine Finish
6 x ⅜ x 1¼	NCD150-P75-BDL-1/8	1A1	613351	6048	662506-13153	Non-Ferrous Med. Finish
	NCD100-P75-BDL-1/8	1A1	601731	6048	662506-13151	Non-Ferrous Roughing
6 x ½ x 1¼	BN150-W-BBL-1/8	1A1	6017A1	6048	662506-13510	Tool Steel-Med. Finish
	NCD100-R100-BDL-1/8	1A1	601741	6048	662506-13488	Non-Ferrous Roughing
6 x ¾ x 1¼ 1012-D ¾" Rim Width	BN100-W-BBL-1/16	6A2C	6183E1	6048	662506-13955	Tool Steel-Roughing
	NCD100-P75-BDL-1/16	6A2C	602721	6048	662506-13902	Non-Ferrous Roughing
	NCD220-P75-BDL-1/16	6A2C	602741	6048	662506-13926	Non-Ferrous Fine Finish
	NCD220-P100-BDL-1/16	6A2C	602751	6048	662506-13927	Non-Ferrous Fine Finish
6 x ¾ x 1¼ 1014-D ¾" Rim Width	NCD150-P75-BDL-1/16	6A2C	602711	6048	662506-13914	Non-Ferrous Med. Finish
6 x ¾ x 1¼ 1092-D ⅜" Rim Width	NCD150-P75-BDL-1/16	6A2C	602701	6048	662506-13915	Non-Ferrous Med. Finish
	NCD220-P100-BDL-1/16	6A2C	6513X1	6048	662506-13928	Non-Ferrous Fine Finish
7 x 0.032 x 1¼	BN100-W-BBL-1/8	1A1R	8137L1	5184	662506-84838	Ferrous Cut-Off
7 x 0.032 x 1¼	NCD100-R100-BDL-1/8	1A1R	8137M1	5184	662506-84839	Non-Ferrous Cut-off
7 x 0.062 x 1¼	BN100-W-BBL-1/8	1A1R	9137N1	5184	662506-84840	Ferrous Cut-Off
7 x 0.062 x 1¼	NCD100-R100-BDL-1/8	1A1R	8137P1	5184	662506-84841	Non-Ferrous Cut-Off
7 x ¼ x 1¼	NCD150-R75-BDL-1/8	1A1R	601751	5184	662506-15388	Non-Ferrous Med. Finish
7 x ⅜ x 1¼	NCD150-R75-BDL-1/8	1A1	601761	5184	662506-15494	Non-Ferrous Med. Finish
7 x ⅜ x 1¼	NCD220-R100-BDL-1/8	1A1	6177Q1	5184	662506-15497	Non-Ferrous Fine Finish
7 x ½ x 1⅛	BN150-T-BBL-1/8	1A1	6017F1	5184	662506-16048	Tool Steel-Med. Finish
7 x ½ x 1¼	NCD150-R75-BDL-1/8	1A1	601771	5184	662506-16044	Non-Ferrous Med. Finish
10 x 0.060 x 1¼	BN100-W-BBL-1/8	1A1R	8137Q1	3629	662506-84842	Ferrous Cut-Off
10 x 0.060 x 1¼	NCD100-R100-BDL-1/8	1A1R	8137R1	3629	662506-84843	Non-Ferrous Cut-Off
12 x ½ x 5	BN100-W-BBL-1/8	1A1	813711	3024	662506-84821	Tool Steel-Roughing
12 x ½ x 5	NCD100-R100-BDL-1/8	1A1	813721	3024	662506-84822	Non-Ferrous Roughing
1 x 1 x 5	BN100-W-BBL-1/8	1A2	813731	3024	662506-84823	Tool Steels Roughing
12 x 1 x 5	NCD220-P75-BDL-1/8	1A1	813741	3024	662506-84824	Non-Ferrous Fine Finish
14 x ½ x 5	BN100-W-BBL-1/8	1A1	813751	2592	662506-84825	Tool Steel-Roughing
14 x ½ x 5	NCD100-R100-BDL-1/8	1A2	813761	2592	662506-84826	Non-Ferrous Roughing
14 x 1 x 5	BN220-W-BBL-1/8	1A1	813791	2592	662506-84829	Tool Steel-Fine Finish
14 x 1 x 5	NCD220-P75-BDL-1/8	1A1	813781	2592	662506-84828	Non-Ferrous Fine Finish

CINCINNATI MONOSET Cutter and Tool Grinder
(Older Model Machines)

	Wheel Size	Products Div. Shape	Specifications	C.M. Co. Catalog No.	Speed (RPM)
Supplied as Standard Equipment	3 x 1/4 x 3/4	S/S	12A120-I6-VRW	102757	8276
	3 X 3/8 X 3/4	S/S	12A60-I6-VRW	102758	8276
	3 X 1/2 X 3/4	S/S	12A60-I6-VRW	102759	8276
	3 X 1/2 X 3/4	12Y100	12A60-H6-VRW	102760	8276
	3 X 3/4 X 3/4	Type 5	12A60-H6-VRW	102761	8276
	R 1/S 1 1/2 X 3/8				
	3 1/2 X 1/16 X 3/4	S/S	2A60-Q9-B2	10676	13096
	3 1/2 X 1/8 X 3/4	S/S	2A60-Q9-B2	102756	13096
	Complete Set Of Above Wheels			325607	
Supplied as Standard Equipment	(Newer Model Machines)				
	3 1/2 x 1 1/2 x 3/4	11Y172	12A60-I6-VRW	325535	6547
	4 X 1/16 X 3/4	S/S	2A60-Q9-B2E	325529	13096
	4 X 1/8 X 3/4	S/S	2A60-Q9-B2E	325530	13096
	4 X 1/4 X 3/4	S/S	12A120-I6-VRWE	325531	8276
	4 X 1/2 X 3/4	S/S	12A60-I6-VRWE	325532	8276
	4 X 3/4 X 3/4	Type 5	12A60-H6-VRWE	325533	8276
	R 1/S 2 X 3/8				
	4 X 1/2 X 3/4	12Y302	12A60-I6-VRWE	325533	8276
	Complete Set of Above Wheels			325609	

CINCINNATI MONOSET Cutter and Tool Grinder
Mounted Wheels

	Wheel Size	Products Div. Shape	Specificatins	C.M. Co. Catalog No.
Supplied at Extra Cost	3/16 x 1/4 Mandrel 1/8 x 1 1/4	W152 1/8 x 1 1/4 Mandrel	12A80-L-V6	102751
	1/4 X 1/4 Mandrel 1/8 x 1 1/4	W160 1/8 x 1 1/4 Mandrel	12A80-K-V6	102752
	3/4 x 3/16 Mandrel 1/8 x 1 1/4	B-81 1/8 x 1 1/4 Mandrel	12A120-R-V6	102755
	1/2 X 1/4 Mandrel 3/16 x 1 5/8	W183 3/16 x 1 5/8 Mandrel	12A80-K-V6	102753
	3/4 X 1/4 Mandrel 3/16 x 1 5/8	W201 3/16 x 1 5/8 Mandrel	12A80-K-V6	102754
	1 1/4 X 1/4 Mandrel 1/4 x 1 5/8	W225 1/4 x 1 5/8 Mandrel	12A80-O-V6	107326



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Broaches

Straight and Type 12 Wheels	WA60-I5-V
End Mills	
High Speed Steel	
Type 6 and 11 Cups	WA60-I10-V

Milling Cutters

	High Speed Steel	High Speed Steel	Cemented Carbide
Wheel Type	Conventional	Open Structure	Prefer Diamond
Type 1 Wheels	WA462-J4-V2	WA54-I12-VC	GC60-J9-VP
Type 4 Wheels			
Ingersoll	WA462-J9-V	WA54-I12-VC	GC80-I9-VP
6" and 7"			GC601-K5-B1XS
10"			GC461-J5-BXS
Type 1 Automatics			GC601-K5-B1XS
Type 6 Cup Wheels	LA603-J4-V	WA60-I10-V	GC60-J9-VP
Type 11 Cup Wheels	LA603-J4-V	WA60-I10-V	GC601-K5-B1XS
Type 12 Dish Wheels	WA542-I9-V2	2A54-H11-VF2Q	GC60-I9-VP2

For Cast Alloy Types, we suggest one grade softer.

Reamers

Cylindrical	WA543-I9-V2
Backing Off	WA46-I10-V2

Taps

Fluting	
Small Taps	WA543-I9-V2
Large Taps	WA60-J9-V
Squaring Ends	LA603-J4-V
Cylindrical Grinding of Shanks	LA603-J4-V

Toolroom Cut-Off

7 x 1/16 x 1-1/4	2A60-N6-B90
7 x 1/32 x 1-1/4	2A60-N6-B90

Single Point Lathe and Planer Tools

	High Speed Steel Rough	Finish
Bench and Pedestal Grinding-Straight Wheels		
Wheels up to 8"	LA603-J4-V	WA603-I9-V2
Wheels over 8"	LA603-I4-V	WA603-I9-V2
Plate Mounted, Easy-Mount and Recessed Wheels		
Wheels 6" and 7"	HA36-J9-V	HA60-I9-V
Wheels over 7"	HA36-I9-V	HA60-H9-V

	Cemented Carbide Rough	Finish
Bench and Pedestal Grinding-Straight Wheels	Prefer diamond wheels	
Wheels up to 8"	GC60-J9-VP	GC1002-I7-V8
Wheels over 8"	GC60-J9-VP	GC1002-I7-V8
Plate Mounted, Easy-Mount and Recessed Wheels		
Wheels 6" and 7"	GC60-J9-VP	GC1002-I7-V8
Wheels over 7"	GC60-I9-VP2	GC1002-I7-V8

Tool Room General Recommendations (cont'd.)

Hobs - Barber-Colman Machines

Wheel Type	Conventional	Open Structure	Ceramic
7 x 1/2 x 3/4 B Face 65°	WA60-I9-V2	WA60-I13-V	3WB602-H13-V
10 X 1	LA602-I13-V2	LA60-H11-VF2	3WB602-G11-VF2

Drills

	3/8" and Smaller	Over 3/8"
Offhand Resharpening	LA702-K9-V	LA462-J9-V
Machine Resharpening	LA702-L9-V	LA462-K9-V

Grain Conversions

Company	FMR	CIN MIL	BAYSTATE	NORTON
Regular	A	2A	A	A
Semi-Friable	FA HA	2A 97A/29A	3A 8A	57A 19A
Friable	JA LA WA 36A 13A	32A 9A 12A	 9A 17A	32A 38A 25A
Green	GC	5C	1C	39C
Black	C	6C	C	37C
Mix	RC	7C	3C	74C

CERAMIC GRAINS

Regular	1WB	1MSB	1GA	1SG
	3WB	3MSB	3GA	3SG
	4WB	3MSB	3GA	3SG
	WB	5MSB	5GA	5SG
	6WB	5MSB	5GA	5SG
	BG	MSB	GA	SG

Use V-VC-VF Bonds with WB Grain.

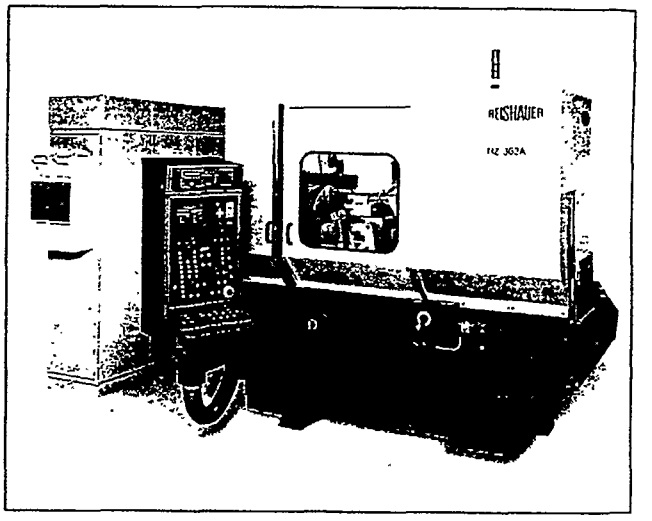
In general, we grade on grade softer thanc ompetitors with WB or MSB.

3 WB-WB 3MSB and 5MSB are the most popular selections.

To reap the full benefits of MSB or WB you must be able to vary grind cycles, pieces per dress and dress depth.

For dry grinding, use WB or 5MSB.

3WB-V is softer than 3MSB-VSA.

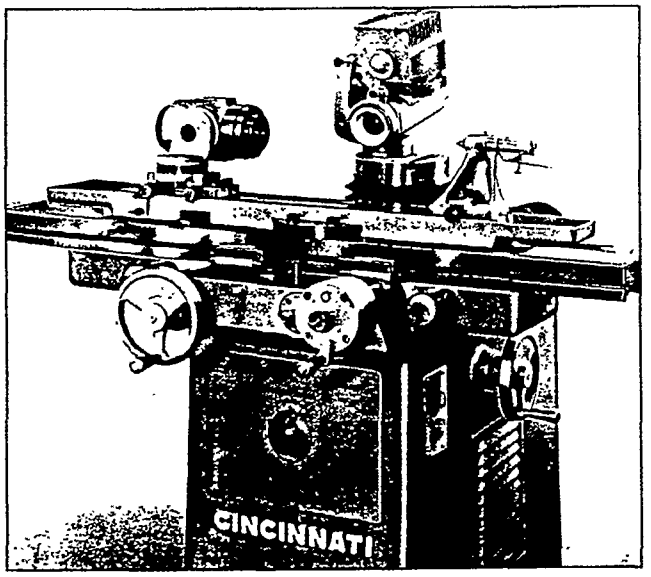


Reischauer Gear Tooth Grinder
Wheel Size: $13^{25}/_{32}$ x $4^{3}/_{32}$ x $6^{19}/_{64}$
Typical Wheel Grade: 9A80-J8-VAE
3MSB801-H8-VSAE

MIL 000208

CINCINNATI No. 1, No. 2 Plain, And No. 2 Universal Cutter & Tool Grinders

Wheel Size	Products Div. Shape		Specifications	C.M. Co. Catalog No.
3½ x 1½ x 1¼	11Y120	#23	9A60-I6-VRW	67783
5 x 1½ x 1¼	6Y112	#24	9A60-H6-VRW	62277
6 X ⅛ X 1¼	S/S	#28	2A60-K9-B2	67782
6 X ½ X 1¼	S/S	#25	9A54-I6-VRW	60479
6 X ¾ X 1¼	12Y155	#21	9A60-I6-VRW	60481
Complete Set Of Above				325608
3½ x 1½ x 1¼	11Y120	#23	5C60-I6-VSC	102843
3½ x 1½ x 1¼	11Y120		5C80-H6-VSC	102844
5 X 1½ X 1¼	6Y112	#24	5C60-I6-VSC	102845
5 X 1½ X 1¼	6Y112		5C80-H6-VSC	102846
6 X ¾ X 1¼	12Y155	#21	5C60-I6-VSC	102847
6 X ¾ X 1¼	12Y155		5C80-H6-VSC	102848
6 X ½ X 1¼	S/S	#25	5C60-I6-VSC	102849
6 X ½ X 1¼	S/S		5C80-H6-VSC	102850
⅝ X ½ X ¼	S/S	#29	9A80-J6-VRW	158178
¾ X ½ X ¼	S/S		9A60-J6-VRW	158179
⅞ X ½ X ¼	S/S		9A80-J6-VRW	99796
1 X ½ X ⅜	S/S	#26	9A80-J6-VRW	158180
8 x 1/16 x 1¼	S/S	#30	2A60-K9-B2	74012
8 X ⅜ X 1¼	S/S	#27	9A46-H6-VRW	65613



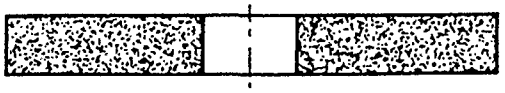
No. 2 MT Cutter and Tool Grinder with power table traverse.

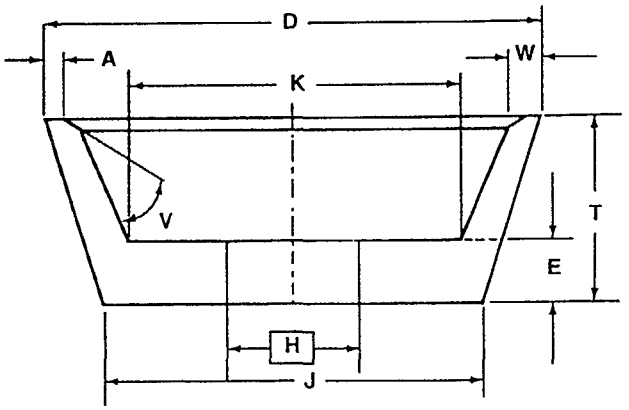
MIL 000209

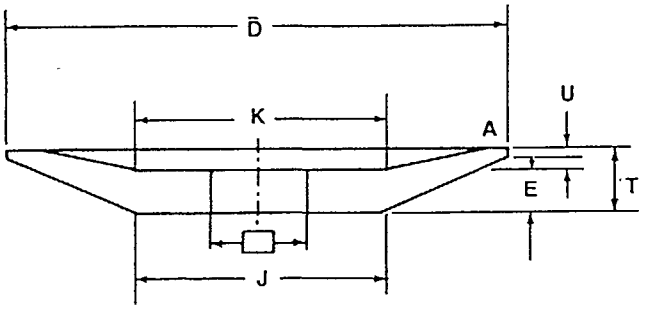
Common Dimensional Standards

The most popular tool room wheel types are straight (type 1), tapered two sides (type 4), straight cup (type 6), flaring cup (type 11), dish (type 12) and saucer (type 13).

Common blueprints for Type 11 and Type 12 wheels are as follows:







Type 1 Wheels

Wheel Size	Shape	Grades Available From Stock		
		9A46	9A60	9A80
6 x 1/2 x 1 1/4	Straight	H	H,I	I
7 x 1/4 x 1 1/4		H,I	H,I,J	I,J
7 x 1/2 x 1 1/4		G,H,I,J	G,H,I,J	H,I,J
8 x 1/2 x 1 1/4		H	H,I	I
8 X 3/4 X 1 1/4		H,I	H,I	

Wheel Size	Shape	Grades Available From Stock		
		9A46	9A60	9A80
10 x 3/4 x 3	Straight	I	H	
10 x 1 x 3		H,I	H,I	
12 x 1 x 3		H,I	H	
12 x 1 x 5		H	H,I	

Type 11 blueprints (hole size usually 1/2 to 1 1/4)

Print No.	Dimensions								
	D	H	W	K	A	E	V	T	J
11Y341-Z	3	1/2	1/4	1-9/16	1/4	3/8	30°	1 1/4	2 1/4
11Y126-Z	3 1/4	1/2	1/4	1 1/2	1/4	3/8	30°	1 1/4	2 1/4
11Y179-Z	3 1/2	3/4	1/4	2 1/4	1/4	3/8	30°	1 1/2	2 1/4
11Y213-Z	4	7/16	1/4	2 3/4	1/4	1/2	30°	1 1/2	3
11Y237	4 1/2	1 1/4	1/2	2 1/4,3	1/4	1/2	NO	1,1 1/4	2 1/4,3 1/4
11Y146	4 1/2	1/2	1/4	3 1/4	1/4	1/2	NO	2	3 1/4
11Y243-Z	5	1/2	1/4	3-1/16, 3 1/4	1/4	1/2	30°	1 1/4	3 1/4
11Y161-Z	6	3/4	3/4	3 1/4, 3 1/4	1/4	1/2	30°	2	4 1/2
11Y297	7	3/4	1/4	3 1/4	3/4	1/2	NO	2	5

Type 12 blueprints (hole size usually 1/2 to 1 1/4)

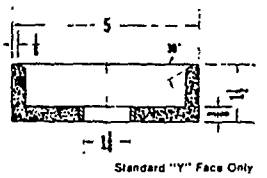
Print No.	Dimensions							
	H	D	A	K	J	E	U	T
12Y116	1/4	3	1/4	1 1/2	1 1/2	5/16	1/16	1/2
12Y305	3/4	3 1/2	3/16	1 1/4	1 1/4	5/16,1/4	3/32	1/2
12Y120	3/4	4	3/16	2	2	5/16	3/32	1/2
12Y280	1/4	4 1/2	1/4	2 1/4	2 1/4	5/16	1/4	1/2
112Y131	1/4	5	1/4	2 1/2	2 1/2	5/16	1/4	1/2
112Y140	1/2	6	3/4	3	3	5/16	1/4	1/2
112Y150	1/2	6	3/8	3	3	3/8	1/4	3/4
12Y363	1 1/4	7	7/16	3 1/4	2 1/4	11/32	1/2	1/2
12Y231	1 1/4	7	1/4 3/4	3 1/4 2 1/4	2 1/4	1/4	1/4	2
12Y123	1/4	8	1/4	4	4	1/4	1/2	1/4
12Y308	1/2	8	1/2	4	4	1/2	1/4	1
12Y208	4	10	2	3 1/4	3 1/2,4	11/16	1/4	1
12Y324	1 1/4	10	2,2 1/4	3 1/4	6 1/4,6	11/16	1/2, 1/16	1,1/16

Additional Sizes & Shapes Available Stocked in Cincinnati

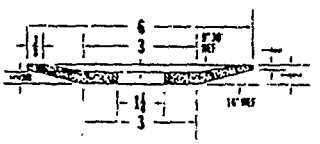
Type 11 And 12 Wheels Available from Stock

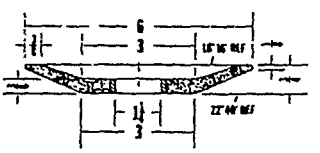
Eliminate flat (⅛ inch) and 30° angle from Types 6 & 11 prints. These wheels are put in stock with a straight rim. If standard "X" face (Type 6) or standard "Y" face (Type 11) are required, program prices are not applicable.

PLAIN CUP WHEEL TYPE 6

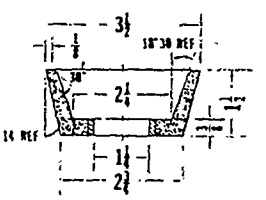


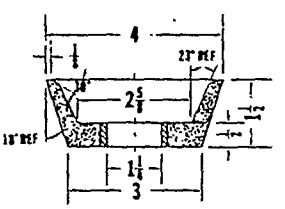
DISH WHEELS TYPE 12

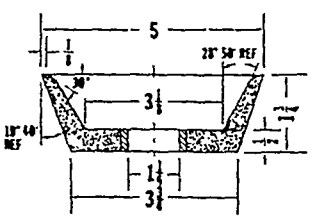




FLARING CUP WHEELS TYPE 11







Wheel Size	Shape	Grades Shown Are Available From Stock		
5 x 1½ x 1¼ R 1/S 4¼ X 1⅛		9A46-G6-VRW 9A46-H6-VRW 9A46-I6-VRW	9A60-H6-VRW 9A60-I6-VRW 12A60-I10-VA 12A60-J6-VA 5C60-J6-VSC	
Wheel Size	**Shape**	**Grades Shown Are Available From Stock**		
6 X ½ X 1¼	12Y145	9A46-G6-VRW 9A46-H6-VRW 9A46-I6-VRW 9A46-J6-VRW	9A60-G6-VRW 9A60-H6-VRW 9A60-I6-VRW 9A60-J6-VRW 12A60-I10-VA 12A60-J6-VA 5C60-J6-VSC	9A80-H6-VRW 9A80-I6-VRW 9A80-J6-VW 9A100-H6-VRW 9A100-I6-VRW 9A120-H6-VRW 9A120-I6-VRW
Wheel Size	**Shape**	**Grades Shown Are Available From Stock**		
6 X ¾ X 1¼	12Y155	9A46-G6-VRW 9A46-H6-VRW 9A46-I6-VRW 9A46-J6-VRW	9A60-G6-VRW 9A60-H6-VRW 9A60-I6-VRW 9A60-J6-VRW 12A60-I10-VA 12A60-J6-VA 5C60-J6-VSC	9A80-H6-VRW 9A80-I6-VRW 9A80-J6-VW 9A100-H6-VRW
Wheel Size	**Shape**	**Grades Shown Are Available From Stock**		
3½ X 1½ X 1¼	11Y120	9A46-G6-VRW 9A46-H6-VRW 9A46-I6-VRW 9A46-J6-VRW	9A60-H6-VRW 9A60-I6-VRW 9A60-J6-VRW 12A60-I10-VA 12A60-J6-VA 5C60-J6-VSC	9A80-H6-VRW 9A80-I6-VRW
Wheel Size	**Shape**	**Grades Shown Are Available From Stock**		
4 X 1½ X 1¼	11Y128	9A46-G6-VRW 9A46-H6-VRW 9A46-I6-VRW 9A46-J6-VRW	9A60-G6-VRW 9A60-H6-VRW 9A60-I6-VRW 9A60-J6-VRW 12A60-I10-VA 12A60-J6-VA 5C60-J6-VSC	9A80-H6-VRW 9A80-I6-VRW
Wheel Size	**Shape**	**Grades Shown Are Available From Stock**		
5 X 1¾ X 1¼	11Y148	9A46-G6-VRW 9A46-H6-VRW 9A46-I6-VRW 9A46-J6-VRW	9A60-G6-VRW 9A60-H6-VRW 9A60-I6-VRW 9A60-J6-VRW 12A60-I10-VA 12A60-J6-VA 5C60-I6-VSC 5C60-J6-VSC 5C60-H10-VSC	9A80-H6-VRW 9A80-I6-VRW 9A80-J6-VRW 5C80-I6-VSC 5C100-I6-VSC

All wheels have glued-on blotters

MIL 000211

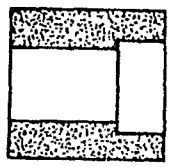
Grinding Wheels For
SPIROPOINT Drill Sharpening Machines
(Numbers in Parenthesis are Cincinnati Milacron Part Numbers)

Collet Mounted Wheels (Old Model)

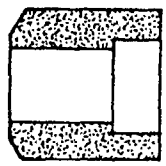
Drill Size	Wheel Grading	Wheel Shape*		
#60 - 1/8	4A220-N4-VFM	1075-Y (710816)	and	1076-Y (710817)
1/8 - 1/2	4A100-M6-VFM	1013-Y (710715)	and	1014-Y (710717)
1/2 - 3/4	4A60-L6-VFM	1013-Y (710716)	and	1014-Y (710630)
3/4 - 1	4A46-K6-VFM	1013-Y (710134)	and	1014-Y (710135)

NOT APPLIED TO MACHINES AFTER AUG. 1960.
**NOTE: Blotters not used*

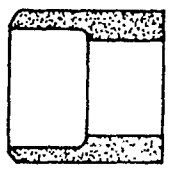
1013-Y



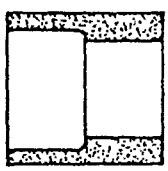
1014-Y



1075-Y



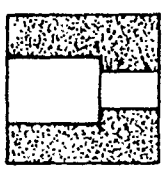
1076-Y



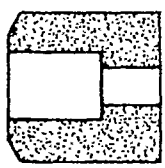
Arbor Mounted Wheels (New Model)

Drill Size	Wheel Grading	Wheel Shape*		
#60 - 1/8	4A220-N4-VFM	1720-Y (710335)	and	1721-Y (710345)
1/8 - 1/2	4A100-M6-VFM	1420-Y (710123)	and	1421-Y (710128)
1/2 - 3/4	4A60-L6-VFM	1420-Y (710144)	and	1421-Y (710146)
3/4 - 1	4A46-K6-VFM	1420-Y (710145)	and	1421-Y (710147)

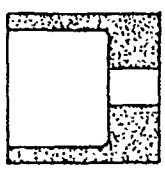
1420-Y



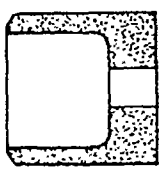
1421-Y



1720-Y



1721-Y



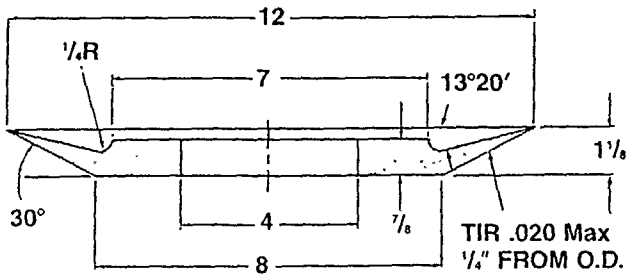
***NOTE: Use blotters when mounting wheels*

MIL 000212

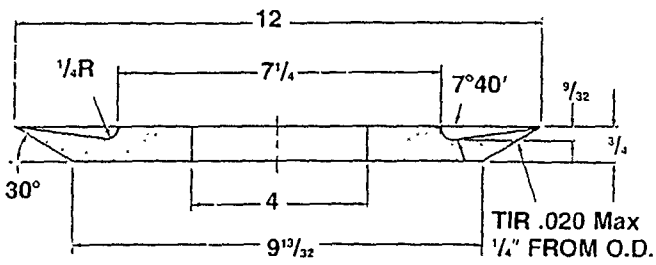
Cincinnati Projecto-Form Grinding Machine

	Wheel Size	Products Div. Shape	Specifications	C.M. Co. Catalog No.
	6 x 1/4 x 1 1/4	S/S	4A120-J6-VFM	None Assigned
	7 x .040 x 1 1/4	S/S	MD150-R100-B1/8	None Assigned
	3 1/4 x 1 1/4 x 7/8	11Y123	9A60-H6-VFM	None Assigned

Special Wheels for GLEASON Gear Cutter Grinders



Typical Grade 9A70-I6-VRW

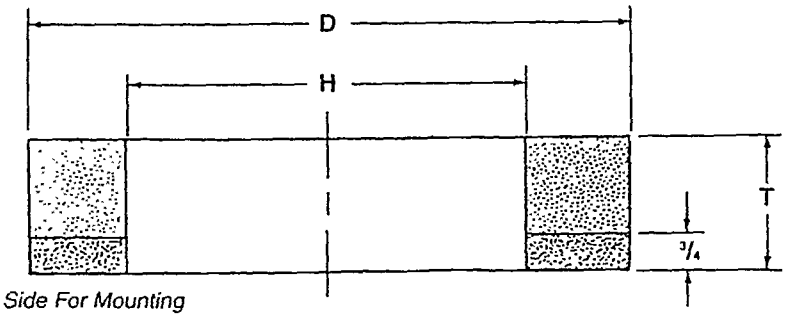


Typical Grade 9A80-J6-VRW

Easy Mount Wheels
Available Grades

Bond Type	Grain Types	Grades		
		4 St.	6 St.	10 St.
VFM	2A, 4A, 9A, 12A, 97A	36-46 H-R	24-30 H-N	24 E-K
		54-80 G-R	36-46 G-N	30-150 D-K
		90-150 F-S	54-80 F-N	
		180-220 F-R	90-120 F-M	
VL	2A, 4A, 9A, 97A		24-80 N-T	24 E-O
			90-100 L-T	30-46 D-N
			120-150 K-S	54-80 D-M
			180 I-R	90-100 D-L
			220 J-P	
VSC	5C, 6C, 7C	24-60 P-U	24-36 G-U	24-36 F-N
		70-220 N-T	46-60 F-U	46 F-M
			70-220 E-T	54-120 D-L

STERLING Easy Mount Wheels



Hard Side For Mounting

MIL 000213

Reishauer Gear Grinding Wheels

A Reishauer (pronounced Rye-Shower) Gear Grinder is essentially a gear hobbing machine with a grinding wheel used in place of teh customary gear hob. The wheel has a thread cut into the O.D. that corresponds to the "Diametral Pitch (DP)" of the gear being ground. Typical sizes would be:

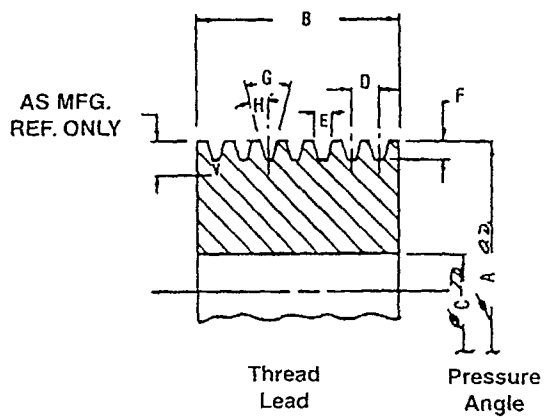
350 x 104 x 160 mm (13.780 x 4.094 x 6.299 in.)
400 x 104 x 160 mm (15.750 x 4.094 x 6.299 in.)
A typical grade would be 9A80-H6-VRW

Cincinnati has the capability of generating the spiral thread form required for these wheels. In order to facilitate orders for these wheels a blank drawing should be requested from Cincinnati so that the customer can supply the information needed to accurately generate the desired form.

The minimum information needed is:

1. Diametral Pitch - D.P.
2. Pressure Angle - P.A.
3. Right Hand or Left Hand Threads
4. Number of Starts
5. Thread Lead

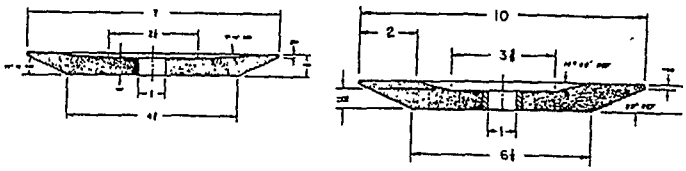
Machine Type	Wheel Size	Standard Rim Widths	Side Relief Angle
HSS60, HSS60/80 HSP-80	280 X 33 X 90 mm (11.024 x 1.299 x 3.543 in.)	4 or 8 mm	13°
HSS60, HSS 60/80	280 x 25½ x 40 mm (11.024 x 1.004 x 1.575 in.)	3, 6 or 9 mm	5°
HSS-90P	340 x 27 x 55 mm (13.386 x 1.063 x 2.165 in.)	6, 8 or 12 mm	6°
HSS-90S	340 x 29 x 150 mm (13,386 x 1,142 x 5.906 in.)	6, 8 or 12 mm	10°
SHS-150S	450 x 29 x 127 mm (17, 716 x 1,142 x 5 in.)	5, 10 or 12 mm	5°
HSS-360	500 X 41 X 160 mm (19.685 x 1.614 x 6.299 in.)	10 mm	10°



MIL 000214

Special Wheels For Barber Colman HOB Grinders

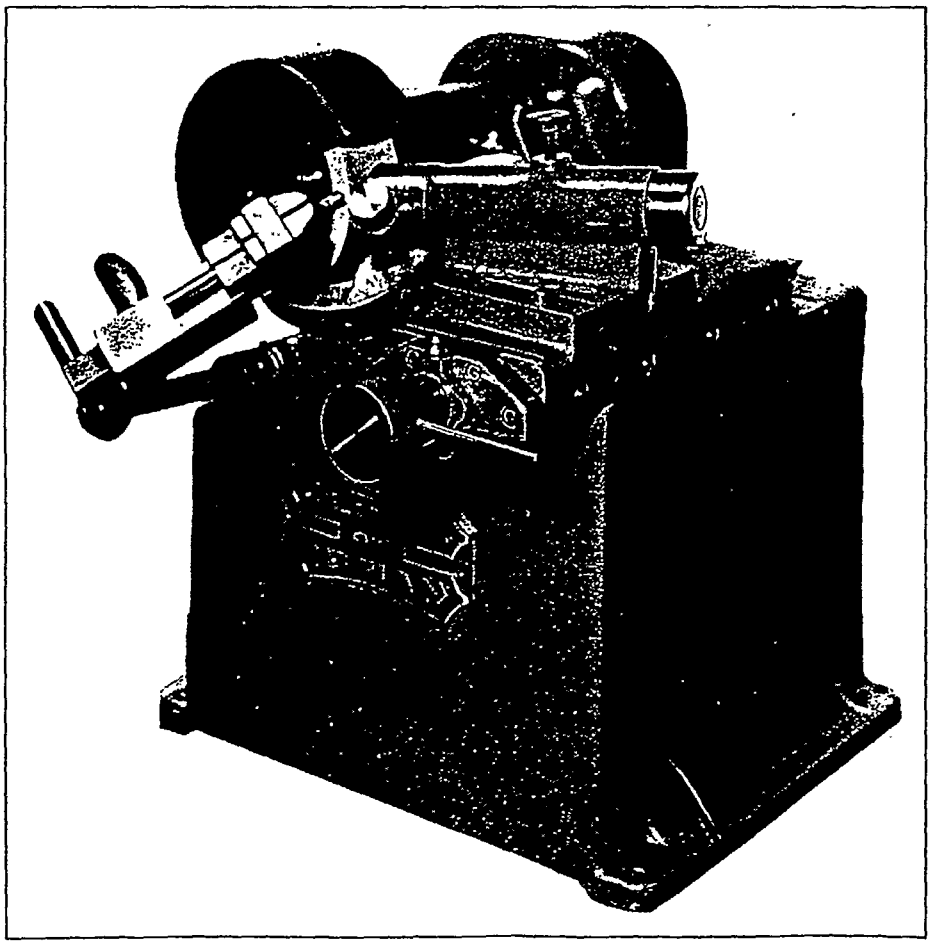
Prints shown above are typical. Other prints of varying design and overall dimensions are on file in Cincinnati. 9A46-H6-VRW would be a typical grading.



Special Wheels For Maag Gear Grinders

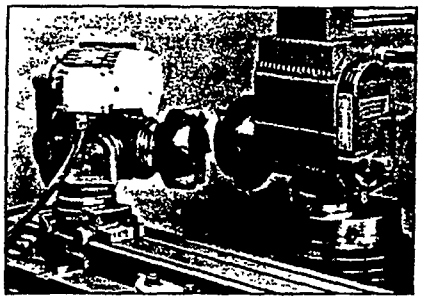
Maag, a Swiss company, manufactures a number of these machines. Some machine types and wheel information associated with these machines are listed below. There are some Maag prints on file in Cincinnati. Fully and accurately dimensions drawn are needed to generate Cincinnati prints for new items. A typical wheel grade would be 9A60-G6-VRW.

Machine Type	Wheel Size	Standard Rim Widths	Side Relief Angle
HSS-10, HSS-30	220 X 20 X 90 mm (8.661 x .787 x 3.543 in.)	2, 4 or 6 mm	12°
HSS-10, HSS-30	220 x 17 x 40 mm (8.661 x .669 x 1.575 in.)	2, 4 or 6 mm	5°



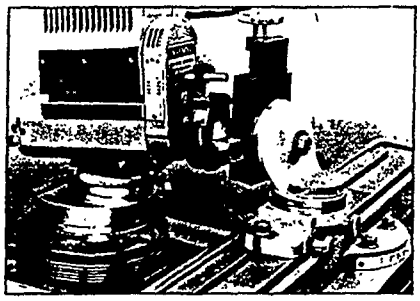
Model 21 Drill Pointer
Wheel Size: 5 x 2 x 5/8
Recessed or Plate Mounted
Typical Grade: 9A60-J4-VFM
29A801-J4-VA

MIL 000215



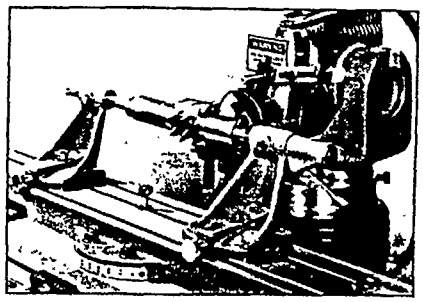
Rough grinding the chamber of a sintered carbide face mill—cutter is rotated by the cylindrical grinding attachment.

AMD100-R100-B5 — dry
CMD100-R100-B — wet



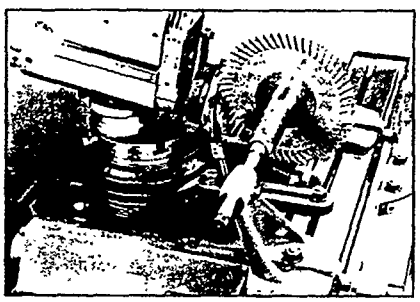
Grinding a relief angle on a carbide lathe tool—the tool shank is held in the surface grinding attachment, equipped with an intermediate swivel support.

AMD120-P100-B5
CMD120-P100-B



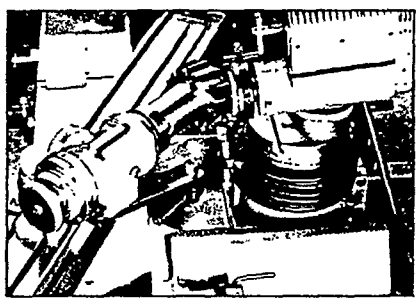
A typical setup to grind a plain milling cutter—the cutter clearance angle is obtained by lowering the toothrest below the center of the cutter.

9A80-I6-VRW
3MSB801-I6-VSA
1BN100-W-B7



Sharpening the teeth on a 10" diameter saw—this setup is greatly simplified by the tilting wheelhead and universal toothrest plate.

9A80-I6-VRW
1BN100-W-B7
3MSB801-I6-VSA

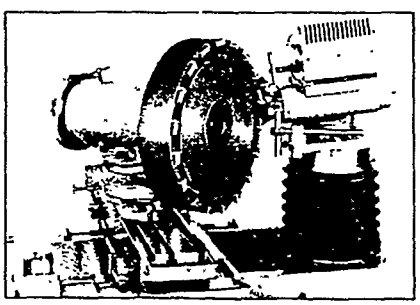


Ecccentric wheelhead and swivel table provide added range to grind the face of this extended shell end mill.

9A60-H6-VRW
1BN80-Q100-B4
3MSB801-H6-VSA

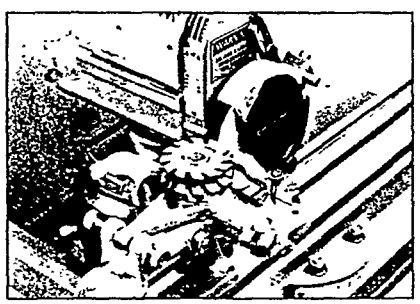
The No. 2 radius grinding attachment includes a micrometer device, used to accurately determine the correct radius.

9A80-I6-VRW
1BN100-Q100-B4
3MSB801-I6-VSA



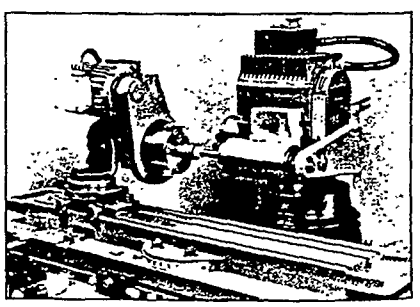
All grinding operations on this large face mill are performed using the face mill grinding attachment. This setup provides ample vertical range and rigid table support.

9A80-H6-VRW
1BN120-W-B7
3MSB801-H6-VSA



Grinding the tooth face of a form relieved milling cutter, using the gear cutter charpening attachment.

9A100-I6-VRW
1BN120-S100-B4
3MSB801-I6-VSA

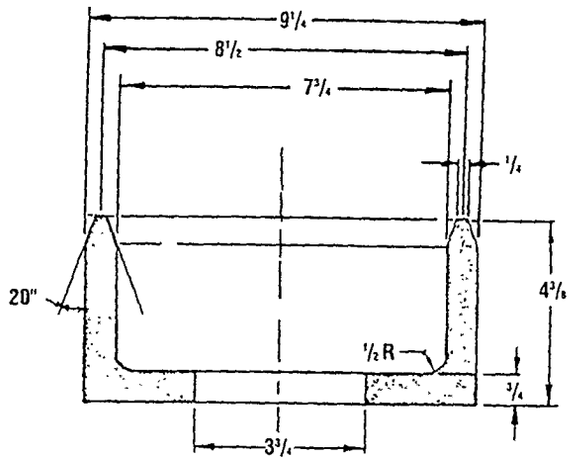


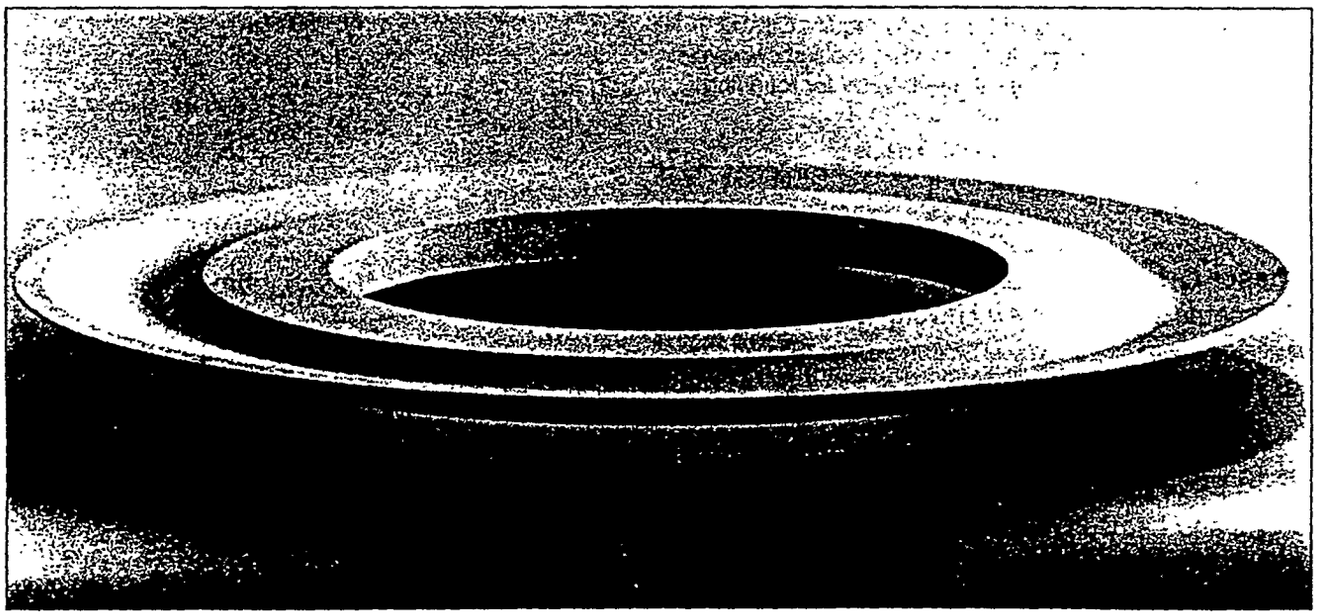
The internal grinding attachment is ideal for light toolroom operations, such as grinding the I.D. of this bushing.

9A100-K6-VFM
1BN120-Q100-B4
3MSB1001-K6-VSA

Gleason Cup Wheel

Cup wheels used on Gleason grindes range in diameter from 3" thru 22" and are generally 4 3/8" thick. this is a low speed (generally 4000-6000 SFPM) and light stock removal operation. The cup rim will normally be angled 20 to 30° from the sides of the rim wall to either a sharp point or a flat, 1/4" wide in most cases. The inside corner of the recess has either a radius or bevel at the base for added support because of the relatively long length of the rim wall. On occasion, the inside wall of the recess is sulfur painted to help retain coolant in the cutting. These wheels are identified as a 6Y type with a numbered suffix. Example: 6Y-1620 is used to describe the wheels hown above. Many prints of Gleason cup wheels are on file in Cincinnati. Contact for information about other sizes and designs.





Gleason Gear Tooth Grinding Wheel

MIL 000217

Toolrooms are found in almost all manufacturing plants throughout the country. They may be called by other names, such as storeroom, machine shop, or repair shop, but the work done is virtually the same: the maintenance and repair of the cutting tools used in the manufacturing operation.

Various types of grinding are done in tool rooms, such as:

1. Tool and cutter grinding — milling cutters, reamers, end mills, etc.
2. Surface grinding — generally wheels 10" diameter and smaller.
3. Cylindrical grinding — generally wheels 16" diameter and smaller.
4. Internal grinding.
5. Drill grinding.
6. Off-hand grinding with mounted wheels and grinding of the lathe and planer tools.
7. Cutting-off of drills and reamers.

Wheels of all sizes and shapes are used. Most wheels are vitrified in grit sizes 36 to 220 and in grades H through N.

Most toolroom grinding is done with friable abrasives, 9A-12A-WA-VA and many of these jobs require CBN. A typical toolroom wheel grade for grinding tools shown on the preceding page would be 9A60-I6-VRW for roughing and 9A80-H6-VRW for finishing.

Carbide grinding requires diamond wheels.

Typical Machine Manufacturers

Alina	Grand Rapids
American Drill	Hammond
Baldor	Heald
Barber-Coleman	Hisey-Wolf
Black & Decker	Hybco
Black Diamond	Ingersoll
Blake	Jones & Lamson
Blount	Jones & Shipman
Brown & Sharpe	Landis
Cawi	LaSalle
Cincinnati	K.O. Lee
Covel	Mohawk
Delta	Norton
Detroit	OKTool
DoAll	Oliver
Dunmore	Omark Winslow
Ex-Cell-O	Royal Oak
Gallmeyer & Livingston	Sellers
Geometric	Sundstrand
Gleason	Wickman
Gisholt	Winslow

Chaser Grinding

Geometric Tool Co., New Haven, CT

Machine/Model	Wheel Size	Type
No. 1G (Old Style)	9 x 1/2 x 1 1/4	T-1
and No. 20	12Y224	T-12
	9 x 3/4 x 1 1/4	
No. 1G	9 x 1/8 x 7	T-1

Jones and Lamson Machine Co., Springfield, VT

Machine/Model	Wheel Size	Type
J & L Bench	6 x 3/4 x 1/2	T-1
Chaser Gdr.	6 x 1 1/2 x 1/2	T-6
	R 1/S 5 1/4 x 1 1/8	

Landis Machine Co., Waynesboro, PA

Machine/Model	Wheel Size	Type
"O"	7 x 1/2 x 5/8	T-1
	6 x 2 x 5/8	R 1/S 5 x 1 1/4 T-6
"Y"	12 x 1 1/2 x 1	T-1
	12 x 2 1/2 x 7	T 1/S 9 x 1 5/8 T-6
"1"	12 x 1 x 1	T-1
	12 x 2 1/2 x 7	R 1/S 9 x 1 5/8 T-6
"1"*	14 x 1 x 1	T-1
	14 x 2 1/2 x 7	R 1/S 9 x 1 5/8 T-6
"1 1/2"	12 x 1 1/2 x 1	T-1
	12 x 2 1/2 x 7	R 1/S 9 x 1 5/8 T-6
"1 1/2"*	14 x 1 1/2 x 1	T-1
	14 x 2 1/2 x 7	R 1/S 9 x 1 5/8 T-6
"2"	18 x 2 x 1 1/2	T-1
	18 x 2 1/8 x 11 1/2	T-6
		R 1/S 15 1/2 x 1 7/8

Drill Grinding Machines

Alina Corp., Plainville, NY

Machine/Model	Wheel Size	Type
2-32	5⅞ x 1½ x 50MM	T-1
SELECT-O-POINT		
03-6	4⅞ x 1⅜ x 50MM	T-6
05-8	R 1/S 4⅛ x 1	
01-2	3 x ¾ x 16MM	T-6
	R 1/S 2½ x ½	

Black & Webster, Waltham, MA (formerly Black Diamond Saw and Machine Works, and Worcester Drill Grinder.)

Machine/Model	Wheel Size	Type
BLACK DIAMOND Drill	7 x ¾ x ½	829-Y
Gdr.	6 x ¾ x 1⅛	T-1
WORCESTER Drill Gdr.	6 x 1¼ x 1⅛	T-6
	R 1/S 3¾ x ¾	
	9½ x 1½ x 1½	T-6
	R 1/S 6½ x ⅞	
	10 x 1 x ⅞	T-1
Black & Webster Models		
BW-70	6 x ¾ x ½	T-1
BW-75		
BW-80		
Black & Webster Models		
BW-55	6 X ¾ X ½	T-1
BW-60		
BW-65		
Black Diamond Models		
1,2,3	7 x ⅞ x ☐	T-1

Brierly Drill Grinder, Des Plaines, IL (Machine & Fixtures)

Machine/Model	Wheel Size	Type
Model ZB	7 x 1 x 3½	T-1
Point Thinning ZB	6½ x ¾ x 1	T-1
New Model	10 x 4 x 5¼	T-6
	R 1/S 7½ x 3	

Covel Mfg. Co., Benton Harbor, MI (YANKEE Drill Grinders)

Machine/Model	Drill Capacity	Wheel Size	Type
JB-Pt. A	¼ to 1½"	9½ x 1½ x 1½	T-6
JBP-Pt.		R 1/S 6½ x ⅞	
F-Pt.A	⅜ to 2½"		
FD-PtA			
WPLA	No. 30 to 2½"		
F-Pt.	½ to 4"	12 x 1½ x 1½	
FO-Pt.			no
WFJ	¼ to 4"		Cin. print
WFL	No. 30 to 4"		
No. 44	No. 30 to 1½"	7 x 1 x 1 1/16	T-5
		R 1/S 4½ x ½	

Dunmore Company, Racine, WI

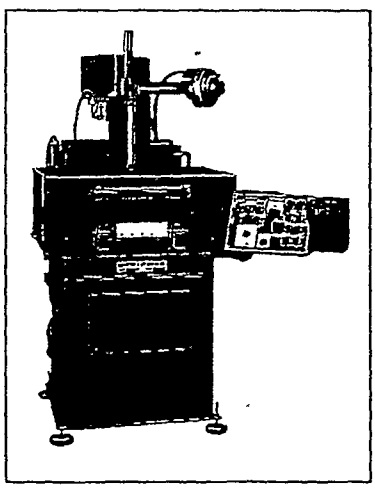
Machine/Model	Wheel Size	Type
DUNMORE Drill Gdr.	2 x ⅜ x .250	T-1
	2 x ⅜ x .250	
	2 x 1/16 x .250	T-1
	for web grinding	

Gallmeyer and Livingston Co., Grand Rapids, MI

Machine/Model	Wheel Size	Type
A7T, B7T, 20-BB6T,	8½ x 1½ x 1	T-5
B5T, A5T	R 1/S 5½ x 1	
C6A,D6A,C6T,D6T,C5T	10½ x 1½ x 1	T-5
10A, 10B, 10C	R 1/S 6½ x 1	
CWA, DWA	12 x 1½ x 1	T-5
	R 1/S 8 x 1	

Grob & Tesker, Grafton, WI (formerly Ted Grob)

Machine/Model	Wheel Size	Type
#300	15 x 2½ x 5	T-5
	R 1/S 7¼ x 1	
#100	8 x 15/16 x 3	T-5
	R 1/S 4⅛ x ⅜	
	8 x 1¼ x 3	T-5
	R 1/S 4⅛ x 7/16	



Gallmeyer & Livingston VRT Rotary Surface Grinder
Wheel Size: 8 x 3 x 3, R1/S 7 x 2¼
WA461-F12-VC
29A461-G10-VA

MIL 000219

Hisey-Wolf Machine Co., Cincinnati, OH (Heavy Duty Drill Grinders)

Machine/Model	Wheel Size	Type
IJA and IJD Max.	6 x 1½ x ½	R 1/S 3¼ x ½ T-5
11/4" drills	6 x ¾ x ½	T-1
2JA and 2JD	7 x 1½ x ⅝	R 1/S 4½ x ½ T-5
Max. 2½" drills	7 x 1 x ⅝	T-1
3JA and 3JD	10 x 1½ x ¾	R 1/S 6 x ½ T-5
Max. 2½" drills	10 x 1 x ¾	T-1
3JJA and 3JJD	10 x ½ x ¾	R 1/S 6 x ½ T-5
3/8" to 2½"		
3JWA and 3JWD	10 x 1½ x ¾	R 1/S 6 x ½ T-5
No. 60 to 2½"		
	10 x 1 x ¾	T-1
3JJWA and 3JJWD	10 x 1½ x ¾	R 1/S 6 x ½ T-5
1/8" to 2½"		
Bench Drill Grinders		
JA and JD	6 x 1¼ x ½	R 1/S 3¾ x ½ T-5
No. 60 to 3/8"	6 x ¾ x ½	T-1

Holland Co., Cleveland, Ohio and J & A Machinery, El Paso, TX

Machine/Model	Wheel Size	Type
"THE CHAMP"	7 X 1½ X 1¼	R 1/S 4 X 1 T-6

Kurt Orban Co., Inc., New York, NY

Machine/Model	Drill Capacity	Wheel Size	Type
CAWI Drill Gdr.	½ to 1"	10 x 1 x *	T-1
	⅛ to ½"		
	12 to 1"	10 x 1½ x *	T-1
	⅛ to ½"		
	Web Thinning		
	High Speed	6 x 5/16 x ⅞	T-1
	Only		

*State whether wheel with 2 or 5 hole is required.

LaSalle Tool Co., Ottawa, Canada

Machine/Model	Wheel Size	Type
AMERICAN Drill Gdr.	8½ x 1½ x 1	T-6
	R 1/S 5½ x 1	

Lisle Corporation, Clarinda, Iowa

Machine/Model	Wheel Size	Type
DG3	5 x ⅝ x ¾	T-1

McDonough Mfg. Co.

Machine/Model	Wheel Size	Type
STERLING	6 x 1½ x ½	T-6
DADB-DFDV	R 1/S 4 x 1	

Mohawk, Montpelier, Ohio

Machine/Model	Wheel Size	Type
48	8 x ¼ x ⅝	T-1
49, 100	8 x 1½ x 4½	
	Rim 1¾" 1P293	
71	8 x 1½ x 4½	
	Rim 1¾" 1P293	
302	12 x 1 x 3	T-1
308	12 x ¼ x 3	T-1
	12 x ½ x 3	T-1
	12 x 1 x 3	T-1
408	14 x ¾ x 5	T-1
	14 x 2½ x 5	T-1

Oliver Instrument, Adrian, MI

Machine/Model	Wheel Size	Type
No. 21 Drill Pointer	5 x 2 x ⅝	R 1/S 4 x 1½
Drill Point Thinner	6 x ⅛ x 1¼	T-1
	6 x ½ x 1¼	T-1
No. 5 or No. 51	9 x 2¼ x 4⅝	S-119
Drill Pointer		
No. 4 Drill Pointer	8 x 2¼ x 5⅛	R 1/S 5½ x
124/32		
No. 510 Drill Pointer	7 x 2 x 4 15/16	1P232
Rim 11/32		
	Plate Mounted	
	(7 x ⅛ x 2)	
	8 x 2 x 5	1P230
	Rim 1½"	
	Plate Mounted	
	(8 x ⅛ x 2)	
No. 510 or No. 600	9 x 2 x 4 15/16	1P131
Drill Pointer	Rim 21/32"	
	Plate Mounted	
	(9 x 1/9 x 2)	

Omark Winslow Co., Arcadia, CA)

Machine/Model	Wheel Size	Type
HC Drill Pointer	12 x ¾ x 5	1
ESACTAMAIC	12 x ¾ x 5	1
800	3 x 3/16 x 2.015	1

MIL 000220

S.R.D. Cone Grind Drill Point Grinder - U.S.A. (import)

Machine/Model	Wheel Size	Type
DG-76M	1⅝ x 1½ x ⅜-16	R 1/S 1 x 1 T-6

William Sellers Div. Consolidated Mach. Tool Corp. Rochester, NY

Machine/Model	Wheel Size	Type
1G (Old Style) Formerly 05D)	5 x 1½ x 1⅛" Rim ¾", ½" back	R 1/S 3½ x 1
4G	6 x 1½ x 4¼" Rim ⅞" Plate Mounted (6 x 3/16 x 1⅝)	1P119
6G (New Style)	8 x 3 x 5½" Rim 1½" Plate Mounted (8 x 3/16 x 3⅛)	1P161
6GA (New Style)	10 x 2 x 7½" Rim 1¼" Plate Mounted 10 x ¼ x 3.750"	1P180

Hob Grinding

Klingelnberg, Germany

Machine/Model	Wheel Size	Type
AGW 160	7⅞ x 11/16 x 2	T-1
AGW 231	10 x ¾ x 2	T-1

Lathe And Planer Tool Grinding

Blount, Milford, NH

Machine/Model	Wheel Size	Type
Models B and BG	12 x 3 x 8, Rim 2" Steel Plate (12 x ⅛ x 1)	IP-425
Models J and G "Old Style"	12 x 2 x 1¼ 14 x 1½ x 4	T-1 T-1

Gisholt, Madison, WI

Machine/Model	Wheel Size	Type
GISHOLT	(10) x 5½ x 4	11Y228

Norton Co., Worcester, MA

Machine/Model	Wheel Size	Type
"BURA-WAY"	7 x 1½ x 3, Rim 2" Plate Mounted (7 x ⅛ x 1¼")	1P111

Oliver Machinery, Grand Rapids, MI

Machine/Model	Wheel Size	Type
Variety #384	6 x 1½ x ¾ 8 x ½ x ¾	R 1/S 4 x 1 T-1
Variety #585	8 x 2 x ¾ 8 x ½ x ¾	R 1/S 6½ x 1¼ T-1

Sundstrand Machine, Dearborn, MI

Machine/Model	Wheel Size	Type
SUNDSTRAND	10 x 3 x 1.250 R 1/S 8 x 2¼ 10 x 2¾ x 7½, Rim 1¼" Plate Mounted (10 x ⅛ x 1¼) or (10 x ⅛ x 2)	T-6 IP-426 IP-427

Tap Grinding

Detroit Tap and Tool Co., Detroit, MI

Machine/Model	Wheel Size	Type
DETROIT Tap Grinder	6 x 1 x ⅝ 6 x ½ x ⅝	

Edward Blake Co., Newton Center, MA

Machine/Model	Wheel Size	Type
BLAKE No. 2 Tap Grinder	6 x 1¼ x ½ 5 x ¼ x ½	R 1/S 5 x ¾ T-1

Hybco Products, Inc., Cleveland, OH (formerly Henry P. Bobbis)

Machine/Model	Wheel Size	Type
HYBCO Tap Grinder	4 x 1 x ½ 3 x ⅛ x ⅜ 3 x 3/16 x ⅜ 3 x ¼ x ⅜ 3 x ⅜ x ⅜ 3 x ½ x ⅜	T-1 T-1 T-1 T-1 T-1 T-1

Gallmeyer & Livingston Co., Grand Rapids, MI (Grand Rapids Tap Grinders)

Machine/Model	Size Capacity	Wheel Size	Type
Tap Grinder	No. 6-1½" Taps	8½ x 1½ x 1	T-6
No. 1		R 1/S 5½ x 1	
		12 x 1½ x 1	T-1
Tap Grinder	⅜-3" Taps	8½ x 1½ x 1	T-6
No. 2		R 1/S 5½ x 1	
		9 x 1 x 1	T-1
Comb. Drill & Tap	No. 6-1½" Taps	10½ x 1½ x 1	T-6
Gdr. No. 10A &		R 1/S 7½ x 1	
10B		12 x 1½ x 1	T-1
Tap Grinder	No. 6-3" Taps	8½ x 1½ x 1	T-6
No. 12		R 1/S 5½ x 1	
Comb. Drill & Tap	⅜-3" Taps	8½ x 1½ x 1	T-6
Grdr. No. 20B		R 1/S 5½ x 1	
Comb. Drill& Tap		10½ x 1½ x 1	T-6
Grdr. No. 20C		R 1/S 6½ x 1	

Oliver Instrument Co., Adrian, MI

Machine/Model	Wheel Size	Type
No. 384 Variety Tool Grdr.	6 x 1⅜ x 3⅝	

Tool And Cutter Grinding

Barber-Coleman

Machine/Model	Wheel Size	Type
Hob Grinder	7 x ⅝ x ¾*	8582-Y
	10 x 1 x 1*	12Y201
	10 x 1 x 1	12Y194
Reamer Grinder*	4 x 1½ x ¾	R 1/S 3½ x 1⅛

*NOTE: This is a high speed machine; check RPM before ordering wheels. Contact Cincinnati Milacron Products Representative.

Gleason Works, Rochester, NY

Machine/Model	Wheel Size	Type
No. 7 Spiral Bevel Cutter Sharpener	8 x 1¼ x 1¼	T-12
No. 9 Automatic Disc	8 x 1¼ x 1¼	T-12
No. 10 Hypoid Cutter Sharpener	12 x ¾ x 4	12Y382
No. 12 Generator	7 x 2 x 1¼	T-6 Cup

Gleason Works, Rochester, NY (cont.)

Machine/Model	Wheel Size	Type
Tool Sharpener	½" Rim ½" Back (7) x 2 x 1¼	Type 11Y147
No. 12 Spiral Bevel Cutter Sharpener (Old Style)	14 x ¾ x 7	
No. 13 Spiral Hypoid Cutter Sharpener	12 x ¾ x 4	12Y382

Ingersoll (Oliver)

Machine/Model	Wheel Size	Type
INGERSOLL Cutter Grinder	10 x ⅜ x 1	T-1
	10 x ½ x 1	654-Y
	10 x ⅜ x 1	T-1

K O Lee Co., Aberdeen, S.D.

Machine/Model	Wheel Size	Type
B300	4 x 1½ x ⅝	11Y-142
	or	
BA900	1¼	11Y-128
B2000	6 x ½ x ⅝	12Y-215
	or	
B6000	1¼	12Y-145

Oliver Machinery

Machine/Model	Wheel Size	Type
Face Mill Gdr.	5 x 2 x ⅝	R 1/S 4 x 1½
#2 or #2A	(3) x 1¼ x ⅝	11Y127
Standard Universal	4 x ½ x ⅝	12Y219
"ACE"	4 x 1½ x ⅝	R 1/S 3¼ x ⅞

Oliver heavy duty "Ace" — same except 1¼" hole

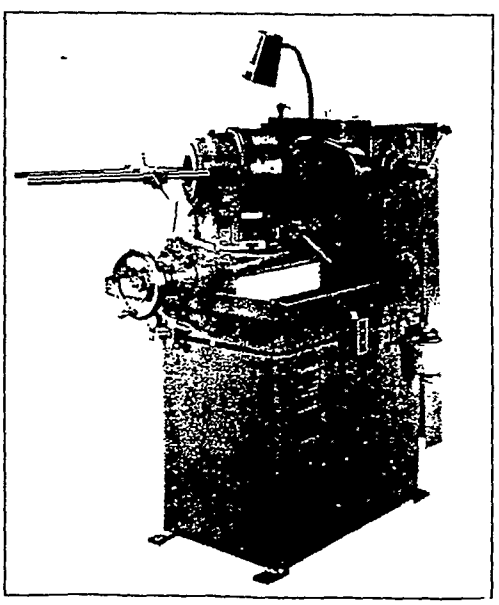


Photo: Oliver 600 Drill Pointer 9 x 2 x 5 Plate Mount
Typical Grade 29A601-K8-VA, WA703-K6-V4
Larger drills require coarser and softer wheel grades

Trouble Shooting

Problem	Possible Causes	Suggested Correction
1. Wheel corner breakdown	Poor wheel dressing.	Dress wheel finer.
	Wheel too coarse.	Use finer grit wheel.
	Wheel too soft.	Use harder grade wheel.
	Worn machine bearings.	Check for run-out and correct.
2. Burning of workpiece	Poor coolant flow.	Increase or direct coolant to grinding contact.
	Wheel acting hard.	Dress wheel coarser or use softer wheel.
	Work speed too slow.	Increase work speed.
	Infeed too fast.	Reduce amount of stock removed per pass.
3. Poor surface finish or quality of grind	Wheel too soft.	Dress wheel finer or use harder grade wheel.
	Wheel too coarse.	Dress wheel finer or use finer grit wheel.
	Poor wheel dressing.	Check diamond sharpness and redress.
	Machine vibration.	Check worn bearings and clamping.
	Dirty coolant.	Clean coolant through filter.
4. Wheel loading or glazing	Wheel too hard.	Use softer grade wheel.
	Wheel too fine.	Use coarser grit wheel.
	Dirty coolant.	Filter coolant or replace with new.
	Poor wheel dressing.	Redress more frequently.

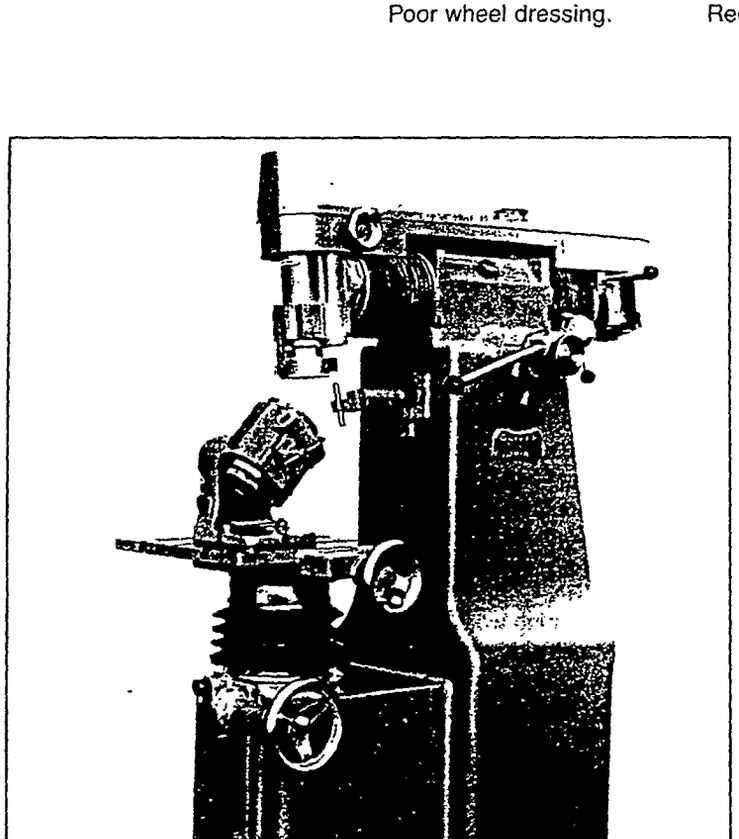


Photo: Oliver 300HD Cutter and Tool Grinder
Wheel Size: 4 x 2 x 1¼ straight cup
4/3 x 2 x 1¼ flare cup
Wheel Grade: 32A46-I6-VFM
3MSB601-H6-VSA

MIL 000223

13 Mounted Grinding Wheels

Offer You These Features

Economy

CINCINNATI MILACRON mounted wheels specified for your jobs combine accurate grading and tough bonds, to give you long life and high stock removal.

Wide range

Cincinnati Milacron offers 215 standard shapes and sizes, including center laps and reinforced resinoid points, in a variety of aluminum oxide and silicon carbide grains and vitrified or resin bonds.

Free cutting

Gradings recommended by Cincinnati Milacron will give you a smooth, fast-cutting grinding action.

Self Dressing

CINCINNATI MILACRON graded wheels virtually dress themselves, because as grits become dull and worn, they break away from the wheel and expose new sharp grits.

Consult us

Your Cincinnati Milacron Marketing Company distributor or sales representative will be glad to help you choose the right wheel. Call us today.

MSB mounted wheels are available in most sizes in typical grades, i.e. 3MSB601-N-VBH.

MOUNTED WHEELS

Application		Recommendation
Steel:	Carbon	A24-R4-BH
	Castings	A30-T5-B254
	Stainless	A36-T6-B254
	Tool-Steel	A46-R5-BH
Iron:	Cast Iron	R5A36-T5-B5
	Diamite	A30-Q4-BC
	Ductile	R5A24-T4-B4
	Grey Iron	R5A36-T5-B5
	Malleable	A36-T5-B254
	Ni-Hard	C30-Q4-BF

Starting Grades

OPERATION

Tool and Die Work (handbarbering) **9A60-N-V6**
Precision Grinding Tungsten Carbide Tools **5C80-L-V8**
Jig Grinding **9A60-M-V6**
General Purpose Work on Soft Steel **9A60- N-V5**
Blending **2A80-I-BX**
Polishing **2A80-G-BXP**
High Finish Polishing **2A220-P-R**
Grinding Non-Ferrous Materials **6C60-U-V7**
Rough Grinding and Deburring **2A60-P-V5**
General Cast Iron Foundry Work **2A30-W-V5**
High Speed Foundry Finishing **2A36-R-BB**
Weld Grinding **2A60-R-V5**

If any of the following characteristics exist the wheel grade may be too hard, or too soft, and a shift in grade may help:

GLAZE — Wheel gets a slick shiny appearance and the cutting action is not free. This happens because the grinding pressures are not great enough to break the bond posts holding the worn grain. Generally under these conditions, the finish has a burnished look and sometimes shows burn marks. A softer grade should be tried.

LOADING — Soft metals (usually below 55 Rockwell C) sometimes leave deposits in the wheel face and inhibit the cutting action. The finish is usually poor because of the galled nature of the cut. Softer and coarser wheels are needed to alleviate this situation.

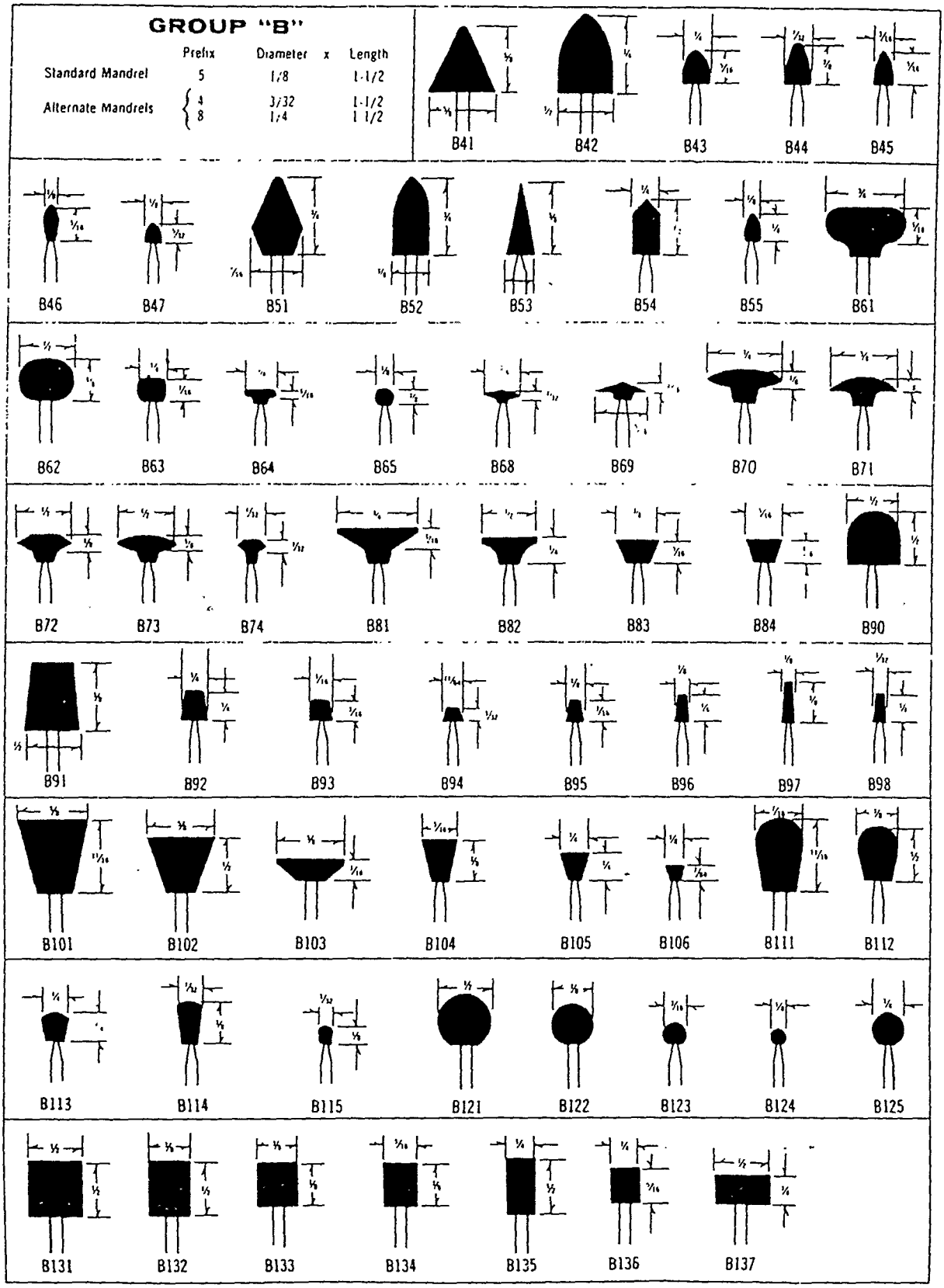
BURN — Burn marks on the piece are a result of grits becoming worn and dull. Under these conditions the wheel rubs rather than cuts the part and the increased friction raises the temperature high enough to oxidize the material. Fine grain wheels show a much greater tendency to burn than do coarse wheels (See "Glaze".) A softer grade should be tried.

BREAKS DOWN TOO FAST — If the point does not hold shape well and finish is poor, a harder wheel should be tried. Fine grain wheels usually hold shape better than coarse grain wheels.

FINISH GETS PROGRESSIVELY WORSE — This is a result of breakdown or load. Use a harder grade if breakdown occurs and a softer grade if the wheel loads.

GROUP "B"

	Prefix	Diameter x	Length
Standard Mandrel	5	1/8	1-1/2
Alternate Mandrels	4	3/32	1-1/2
	8	1/4	1 1/2

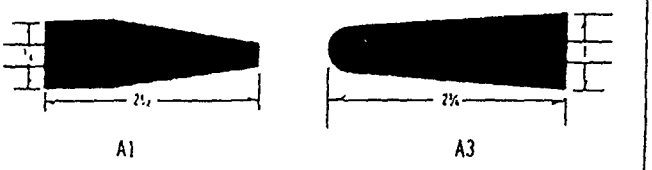


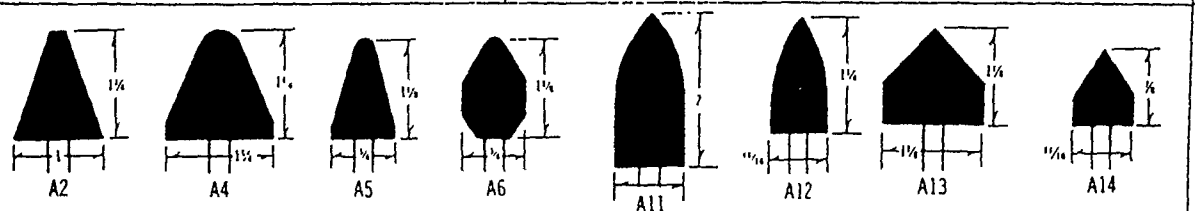
13

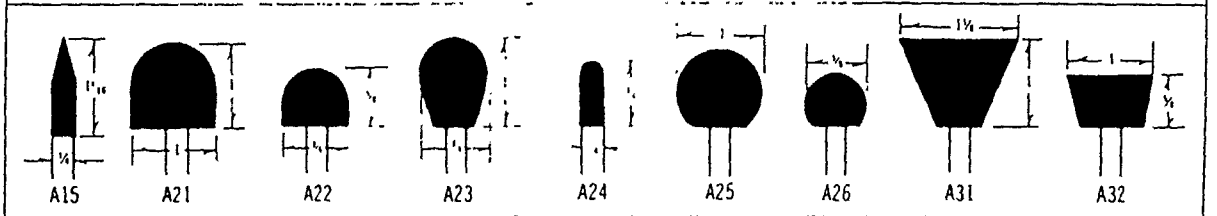
STANDARD SHAPES

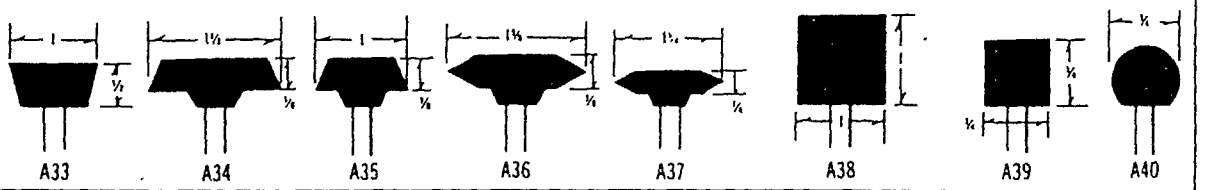
GROUP "A"

	Prefix	Diameter x Length
Standard Mandrel	8	1/4 x 1 1/2
Alternate Mandrels	7	1/4 x 1
	11	3/16 x 1
	12	3/16 x 1-1/2
	13	15/64 x 1
	14	15/64 x 1-1/2



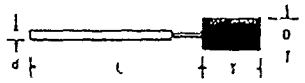






GROUP "W"

STRAIGHT WHEELS



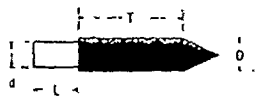
The standard mandrel for the W series is indicated in the table by the prefix before the shape number. Alternate mandrel sizes can be specified by adding a different prefix number as indicated below.

ALTERNATE MANDRELS

Prefix	Diameter (d) x Length (L)
3	3/8 x 1 1/2
4	3/32 x 1 1/2
5	1/8 x 1 1/2
6	1/8 x 2 5/8
7	1/4 x 1
8	1/4 x 1 1/2

Wheel Size D	Wheel Size T	Shape No.
3/32	5/32	SW141
3/32	1/4	SW142
1/8	1/8	SW143
1/8	1/4	SW144
1/8	3/8	SW145
1/8	1/2	SW146
5/32	1/32	SW147
5/32	1/16	SW148
5/32	1/4	SW149
3/16	1/16	SW150
3/16	1/8	SW151
3/16	1/4	SW152
3/16	3/8	SW153
3/16	1/2	SW154
1/64	1/4	SW155
1/4	1/32	SW156
1/4	1/16	SW157
1/4	1/8	SW158
1/4	3/16	SW159
1/4	1/4	SW160
1/4	5/16	SW161
1/4	3/8	SW162
1/4	1/2	SW163
1/4	3/4	SW164
5/16	1/16	SW165
5/16	1/8	SW166
5/16	1/4	SW167
5/16	5/16	SW168
5/16	3/8	SW169
5/16	1/2	SW170
3/8	1/4	SW171
3/8	5/16	SW172
3/8	3/8	SW173
3/8	1/4	SW174
3/8	3/8	SW175
3/8	1/2	SW176
3/8	3/4	SW177
3/8	1	SW178
3/8	1 1/4	BW139
1/2	1/32	SW180
1/2	1/16	SW181
1/2	1/8	SW182
1/2	1/4	SW183
1/2	3/8	SW184
1/2	1/2	SW185
1/2	3/4	SW186
1/2	1	SW187
1/2	1 1/2	BW188
1/2	2	BW189
5/8	1/16	SW190
5/8	1/8	SW191
5/8	1/4	SW192
5/8	3/8	SW193
5/8	1/2	SW194
5/8	3/4	SW195
5/8	1	SW196
5/8	2	SW197
5/8	2 1/2	SW198
3/4	1/16	SW199
3/4	1/8	SW200
3/4	1/4	SW201
3/4	3/8	SW202
3/4	1/2	SW203
3/4	3/4	SW204
3/4	1	BW205
3/4	1 1/4	BW206
3/4	1 1/2	BW207
3/4	2	BW208
3/4	2 1/2	BW209
7/8	1/16	SW210
7/8	1/8	SW211
7/8	1/4	SW212
7/8	3/8	SW213
15/16	1/4	SW214
1	1/8	SW215
1	1/4	SW216
1	3/8	BW217
1	1/2	BW218
1	3/4	BW219
1	1	BW220
1	1 1/2	BW221
1	2	BW222
1	2 1/2	BW223
1	3	3W224
1 1/4	1/4	BW225
1 1/4	3/8	BW226
1 1/4	1/2	BW227
1 1/4	3/4	BW228
1 1/4	1	BW229
1 1/4	1 1/4	BW230
1 1/4	1 1/2	BW231
1 1/4	2	BW232
1 1/4	2 1/2	3W233
1 1/4	3	3W234
1 1/2	1/4	BW235
1 1/2	1/2	BW236
1 1/2	1	BW237
1 1/2	1 1/2	BW238
1 1/2	2	3W239
1 1/2	2 1/2	3W240
1 1/2	3	3W241
2	1	3W242
2	1 1/2	3W243
2	2	3W244
2	2 1/2	3W245
2	3	3W246
2 1/2	1	3W250
2 1/2	1 1/2	3W251
2 1/2	2	3W252
2 1/2	2 1/2	3W253
2 1/2	3	3W254
3	1	3W260
3	1 1/2	3W261
3	2	3W262
3	2 1/2	3W263
3	3	3W264

CENTER LAPS



The Standard mandrel for center laps is indicated in the table by the prefix before the shape number. Alternate mandrel sizes can be specified by adding a different prefix number as indicated below.

ALTERNATE MANDRELS

Prefix	Diameter (d) x Length (L)
7	1/2 x 2 1/2
7	1/4 x 1
9	1/2 x 1 1/8

Wheel Size D	Wheel Size T	Shape No.
1/2	2	7CL189
1/2	2 1/2	7CL247
1/2	3	9CL248
5/8	2	7CL197
5/8	2 1/2	7CL198
5/8	3	9CL249
3/4	2	7CL208
3/4	2 1/2	7CL209
3/4	3	9CL250
1	2	7CL227
1	2 1/2	7CL223
1	3	9CL224

bond types

V5 This unusually tough vitrified bond for aluminum oxide abrasives gives you long wheel life and low costs. With the proper type of aluminum oxide grain you get a smooth, fast cutting action. V5 is specified primarily for grinding iron and steel castings, stainless steel welds, forgings, and forging dies.

V6 A clear and colorless bond that provides a free cutting action for aluminum oxide grains. It has shown excellent results on internal grinding, and hard tool steel work.

V7 A hard durable bond, used in hard grades with 6C black silicon carbide for general purpose portable grinding. V7 covers a wide range of silicon carbide applications.

V8 Used in soft grade silicon carbide wheels for precision grinding, and for grinding cemented carbides, V8 bond provides exceptionally satisfactory results in the softer grades.

BB The general purpose resin bond for all grain types.

BX A reinforced resin bond consisting of alternate layers of abrasive and cotton fibers. Used exclusively with either 2A or 6C grain. This extremely tough bond gives a very fine polishing action.

BXP A reinforced resin bond similar to BX bond, but slightly more resilient. Produces a high polishing action and is well suited for operations where two surfaces are to be blended.

R A somewhat resilient rubber bond used exclusively with 2A or 9A abrasive. Well suited for general purpose work where a fine finish is required.

VBH Special vitrified bond for use with MSB abrasive.

treatments

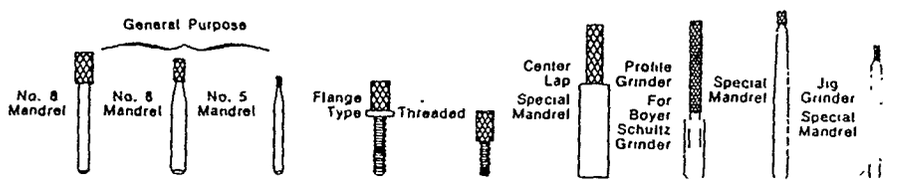
R TREATMENT — The resin is impregnated in the wheel, which when cured, strengthens the vitrified bond posts and reduces the tendency of the wheel to groove when grinding sharp fins or welds, or when deburring. It can also be used in center laps with V6 bond. This treatment adds considerable life to a wheel on such operations.

S TREATMENT — Keeps the wheel clean and free when grinding nonferrous materials. Soft ductile metals like aluminum, brass and bronze tend to load a grinding wheel — S treatment reduced this tendency to a minimum.

B TREATMENT — This sulfur treatment is also available for those customers who find it helpful.

mandrels

Cincinnati mounted wheels can be secured on a complete range of mandrel sizes. Some of the variations are shown below.



Cincinnati Prefix Number	Size	GWI Suffix Designation
2	1/2 x 2 1/2	F4
3	3/8 x 1 1/2	D3
4	3/32 x 1 1/2	Special
5	1/8 x 1 1/2	D1
	Standard size for Series B Mounted Wheels.	
6	1/4 x 2 3/8	Special
7	1/4 x 1	C2
8	1/4 x 1 1/2	D2
	Standard size for Series A Mounted Wheels.	
9	1/4 x 3/8	Special

Note—See chart for Standard mandrels with Series W Mounted Wheels and center laps.

Rigid safety standards have been established by the Grinding Wheel Institute for mandrel diameter and overhang at a given RPM. A booklet, "Mounted Wheels — Safe Efficient Operation and Maximum Operating Speeds", published by the Grinding Wheel Institute, gives specific tables showing these relative speeds. Copies can be secured by writing Products Division of Cincinnati Millacron. The table at the left lists mandrel sizes and the corresponding Cincinnati number designation. These numbers should appear as prefixes to the shape number when specifying. For example, a B101 mounted wheel that is to have a mandrel 1/4" diameter by 1 1/2" long would be written: 8B101.

ordering

For quick handling, your order should specify the following:

1. Shape, number, and quantity desired.
2. Mandrel size — standard mandrels will be supplied unless otherwise specified.
3. Grading desired — or indicate the type and hardness of material to be ground, and results expected.

marking chart

Grain Type	Grain Size			Grade			Bond	Treatment
	Coarse	Medium	Fine	Soft	Med.	Hard	Vitrified	
2A	16	36	100	E	M	Q		
9A	20	46	120	F	N	R	V5	
5C	24	60	150	G	O	S	V6	S—Wax
6C	30	80	180	H	P	Y	V7	B—Sulfur
97A			220	I		U	V8	R—Resin
32A				J		V	VBH	For MSB
MSB				K		W	Resinoid	
				L			BB	
							BX	
							BXP	
							Rubber	
							R	

BX Bond Mounted Points

BX Bond, a hard and heat-resistant bond, is best adapted for snagging or burring, and is available in the following shapes, and in aluminum oxide grain only.

Shape No.	Coarsest Grain Size	Shape No.	Coarsest Grain Size	Shape No.	Coarsest Grain Size
A1	24	W162	36	W213	24
A2	24	W163	36	W214	24
A3	24	W167	54	W216	24
A4	24	W168	54	W217	24
A5	24	W169	54	W218	24
A6	24	W170	54	W219	24
A11	36	W174	36	W220	24
A12	36	W175	36	W221	24
A13	36	W176	36	W222	24
A14	36	W177	36	W223	24
A21	24	W178	36	W224	24
A22	24	W183	24	W225	24
A23	24	W184	24	W226	24
A25	54	W185	24	W227	24
A26	54	W186	24	W228	24
A33	54	W187	24	W229	24
A34	54	W188	24	W230	24
A35	54	W189	24	W231	24
A36	54	W192	24	W232	24
A37	54	W193	24	W233	24
A38	36	W194	24	W234	24
A39	36	W195	24	W235	24
B41	54	W196	24	W236	24
B42	54	W197	24	W237	24
B51	54	W198	24	W238	24
B52	54	W199	24	W239	24
B61	54	W202	24	W240	24
B62	54	W203	24	W241	24
B91	54	W204	24	W242	24
B111	24	W205	24	W243	24
B112	24	W206	24	W244	24
B121	54	W207	24	W245	24
B122	54	W208	24	W246	24
W160	54	W209	24		
W161	36	W212	24		

Check the following limits against those listed above before ordering

Grade And Size Limits
Aluminum Oxide Grain - 24, 36, 54, 80, 120, 180, 320 Grades - H, I Min. size - 1/4 inch OD

BXP Bond Mounted Points

BXP bond, a softer and more resilient bond, is best suited for polishing, and is available in the following shapes, aluminum oxide grain only.

Shape No	Coarsest Grain Size	Shape No	Coarsest Grain Size	Shape No	Coarsest Grain Size
A1	36	W162	36	W213	36
A2	36	W163	36	W214	36
A3	36	W167	36	W216	36
A4	36	W168	36	W217	36
A5	36	W169	36	W218	36
A6	36	W170	36	W219	36
A11	36	W174	36	W220	36
A12	36	W175	36	W221	36
A13	36	W176	36	W222	36
A14	36	W177	36	W223	36
A21	36	W178	36	W224	36
A22	36	W183	36	W225	36
A23	36	W184	36	W226	36
A25	54	W185	36	W227	36
A26	54	W186	36	W228	36
A33	54	W187	36	W229	36
A34	54	W188	36	W230	36
A35	54	W189	36	W231	36
A36	54	W192	36	W232	36
A37	54	W193	36	W233	36
A38	36	W194	36	W234	36
A39	36	W195	36	W235	36
B41	54	W196	36	W236	36
B42	54	W197	36	W237	36
B51	54	W198	36	W238	36
B52	54	W199	36	W239	36
B61	54	W202	36	W240	36
B62	54	W203	36	W241	36
B91	54	W204	36	W242	36
B111	36	W205	36	W243	36
B112	36	W206	36	W244	36
B121	54	W207	36	W245	36
B122	54	W208	36	W246	36
W160	54	W209	36		
W161	36	W212	36		

Check the following limits against those listed above before ordering.

Grade And Size Limits
Aluminum Oxide Grain - 36, 54, 80, 120, 180, 320 Grades - E, F, G, H, I Min. size - 1/4 inch OD

MIL 000228

Definition

Mounted wheels, or "mounted points" as they are frequently called, may be defined as a class of relatively small abrasive wheels, usually under two inches in diameter, and of various sizes and shapes, permanently secured to steel mandrels.

The mounting on the mandrel is accomplished by molding a hole partially through the wheel before the wheel is fired or cured. A steel shaft, knurled on the end, which enters the hole, is cemented in place, usually with a phenolic resin-based cement. In the case of some resin-bonded mounted wheels, the mandrel is molded directly into the wheel and thus becomes firmly fixed when the wheel is oven-cured. This junction is subjected, while grinding, to large mechanical and thermal stresses and must be of high quality. Mounting in this way allows the wheels to be used in a chuck in the same manner as a drill or other rotating tool.

Uses

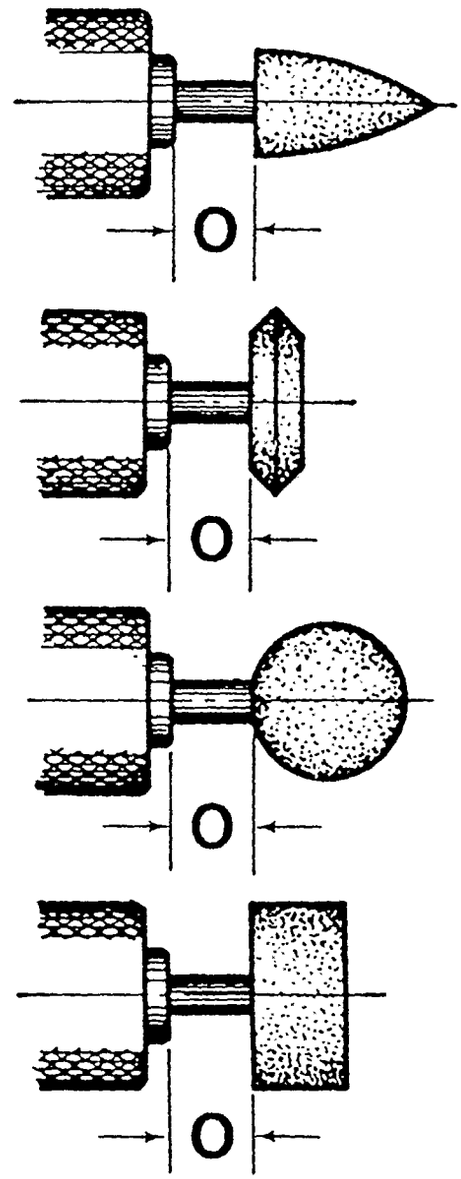
The obvious advantage of mounted wheels is their portability. Used in conjunction with modern high speed portable grinders they can be taken to the work where material can be removed from locations inaccessible to other tools. The small sizes of mounted points (A and B series) are widely used in high speed grinders by tool and die shops for making molds and for grinding of special contours. Straight cylinder shapes (W series) may be used for precision internal grinding. Larger sizes are used chiefly in foundries, weld shops and in machine shops for rough grinding of surfaces which are too difficult to reach with other wheel shapes.

Center Laps

Center laps are special, shaped mounted points that are used to clean out, or straighten the center holes of hardened or heat treated pieces. #7 or #9 mandrel sizes are most commonly used in center laps. Typical designation and grading: 9CL222 2A180-R-V5S

Safety

Mounted wheels have an additional safety requirement not applicable to other wheels. This condition is too often ignored by users. It has to do with the amount of "overhang" when a wheel is mounted in the chuck of a grinder. Increasing the overhang beyond what is absolutely necessary multiplies many times the probability that the mounted wheel will vibrate and whip. This can cause pounding and wheel breakage or bending and breaking of the mandrel. It should be kept in mind that under the best of conditions a shaft supported at only one end is not very stable.



*Note: dimension "O" indicates overhang of mandrel.

MIL 000229

Additional Mandrel Information

Standard Threaded Mandrels — Flange Type

Thread Size	Thread Length
3-56	1/4
5-40	3/8
10-32	1/2
1/4-20	1/2

Special Mandrels

Dia.	Length
1/8	4 or 5"
1/4	4"
1/4	6"
1/4	7"
3/8	3-3 1/2" or less
1/2	7/8-1"
1/2	1 1/2-2 1/2"
3/8-16	16 Thread Flange type 1/2 long.

Availability

All users of mounted wheels should have a copy of the "American National Standard Safety Code for the Use, Care and Protection of Abrasive Wheels." These are available from wheel manufacturers or from the American National Standards Institute. There is also an excellent booklet on safe and efficient operation of mounted wheels published by the Grinding Wheel Institute.

Tables giving maximum operating speeds of all the various standard shapes and sizes of mounted wheels, taking into consideration the amount of overhang, are included in this section. These limits should never be exceeded. If the speed of the grinder is too high, any one or more of four different steps can be taken to bring the set-up within safety rules:

1. Reduce length of mandrel projection.
2. Increase diameter of mandrel.
3. Reduce diameter of wheel.
4. Reduce thickness of wheel.

Grain	Grain Size	Grades	Structure	Bond Types
2A	46-220	I-U	none	V5 or V6
97A	46-220	I-U	none	V5 or V6
9A	46-220	I-U	none	V5 or V6
12A	46-220	I-U	none	V5 or V6
32A	46-220	I-U	none	V5 or V6
6C	46-220	I-U	none	V7
5C	46-220	I-U	none	V7
2A, 97A, 9A	46-220	I-U	none	BB
MSB	46-220	I-U	none	VBH

Treatments

R-Treatment — The resin is impregnated in the wheel, which when cured, strengthens the vitrified bond post and reduces the tendency of the wheel to groove when grinding sharp fins or welds, or when deburring.

S-Treatment — Keeps the wheel clean and free when grinding nonferrous materials. Soft ductile metals like aluminum, brass and bronze tend to load a grinding wheel — S Treatment reduces this tendency to a minimum.

B-Treatment — This sulphur treatment is also available for those customers who find it helpful.

Suggestions for Ordering:

Give the complete specification desired, including abrasive type, grit size, grade, bond, and include a description of the mandrel: mandrel diameter, mandrel length and whether the mandrel is straight, tapered, or threaded. Use standard prefixes if applicable. EX: 5W indicates W shape with 1/8 diameter, 1 1/2" long straight mandrel.

Trouble Shooting

Problem	Possible Causes	Suggested Correction
1. Wheel glazing	Wheel too hard/fine.	Use softer and/or coarser grit wheel.
	Insufficient pressure.	Increase pressure on wheel.
	Wheel speed too high	Reduce wheel speed
2. Chatter marks on workpiece	Mandrel overhang too large.	Reduce overhang of mandrel
	Bent mandrel	Check wheel/mandrel for truth
	Wheel too hard.	Use softer acting wheel
3 Burning of workpiece	Wheel too hard	Use softer grade/coarser grit wheel.
	Insufficient pressure.	Increase pressure/stock removal per pass
	Poor coolant flow (where used).	Increase coolant flow
	(Also, see Internal Grinding)	

MIL 000230

14 Abrasive Cut-Off Wheels

The Cutting-off Machine

There are a number of different types of machines on the market for either dry or wet, hand-operated or automatic, cutting. The types most commonly used are:

The chop-stroke - the original, and still widely used cutting off machine. With the workpiece held securely in a fixed position, the wheels cut down through the work. Workpiece capacity is dependent upon the wheel diameter and horsepower of the wheel drive motor.

The rotating-work machine is normally in the class of automatic type cutting-off machines. Its features are reduced area of contact and high unit pressures; also, it can handle larger workpieces than other type machines. This follows from the fact that the wheel cuts only to the center of the rotating bar stock or other workpiece. By using rotating chucks to hold the work, it is possible to cut large cross-sections of shapes other than rounds.

The oscillating wheel head machine simulates a sawing action as it cuts. this machine had advantages over the plain chopper-type machine in that the area of contact between wheel and work is relatively small, resulting in higher cutting pressures per unit area - hence faster rate of cut. In addition to fast cut, this machine permits the use of more durable wheels, with a resulting savings in wheel costs. Again, work capacity is dependent upon wheel diameter and horsepower of the drive motor.

In traverse machines either the cut-off wheel or the work is mounting on a sliding table, rails or ways. The advantage to this work holding method is that long cuts can be made on large sheets, slabs or other flat stock.

Material	Method	Grade
Alnico	Wet	2A46-M-RS
	Dry	2A54-P9-B2S
Aluminum Tubing & Thin Section	Wet	2A46-O-RS
Heavy Sections	Dry	2A30-P9-B2S
Aluminum Bronze		
Bar Stock	Dry	2A30-P9-B2
Castings-Gates & Risers	Dry	2A24-P-BF9
Bits		
Coal Mining	Dry	2A36-R9-B90
Coal Mining	Wet	2A36-P-R
Blades - Turbine	Wet	2A46-N-R
Manual Op. Machines	Wet	2A54-P-R
Brake Lining	Dry	6C24-R9-B2S
Reinforced	Dry	6C24-P-BF9
Brass & Bronze		
Bar Stock & Heavy Sections	Wet	2A36-Q-RS
Bar Stock & Heavy Sections	Dry	2A36-R9-B2
Tubing & Thin Sections	Wet	2A36-Q-RS
Tubing & Thin Sections	Dry	2A36-Q9-B2S
Gates, Risers, Castings (Reinforced)	Dry	2A24-R-BF9
Brick (Building)	Dry	6C24-R-BF9
Refractory	Dry	6C24-R-BF9
Cable - Steel	Dry	2A36-S7-B90
Less Burr	Wet	2A46-P9-B2S
Carbon		
Soft	Dry	6C36-R9-B90
Hard	Dry	6C36-P9-B90
Cast Iron		
(Reinforced)	Dry	2A24-R-BF9
(Non-Reinforced)	Dry	2A36-R9-B90
Celotex		
Reinforced	Dry	6C24-R-BF9
Cemented Carbides	Wet or Dry	MD120-R100-B 1/8
	Wet	CMD120-R100-B 1/8
Ceramics		
Refractories - Porcelain Etc.	Dry	5C36-P9-B90
Chilled Iron		
Chopper Type	Dry	2A36-N9-B90
Chopper Type	Wet	2A46-M-RS
Swing Frame	Dry	2A30-R-BF9
Cinder Block & Concrete Block		
Portable Saw (Reinforced)	Dry	6C24-R-BF9
Copper		
Bars	Wet	2A46-R-RS
Gates & Risers	Dry	2A36-R9-B2S
Gates & Risers (Reinforced)	Dry	2A24-R-BF9
Drills (Cut Off)		
Drill Rod	Dry	2A46-P9-B90
	Wet	2A46-N-R
Fibre		
Board	Dry	6C30-Q9-B90
General Purpose	Wet	2A46-Q-RS
	Dry	2A36-Q9-B90

Material	Method	Grade
Glass		
Thin Wall Tubing	Wet	6C120-J6-RS
Heavy Wall Tubing	Wet	6C120-L6-RS
Gypsum		
(Reinforced)	Dry	6C24-R-BF9
Inconel		
Bar Stock	Dry	2A36-N9-B2S
Bar Stock	Wet	2A60-M-RS
iridium (Pen Points)		
Cut Off & Slotting	Wet	2A240-R-R
Iron Alloys		
Ductile	Wet	2A24-P-R
Ductile (Reinforced)	Dry	2A24-R-BF9
Knives (Machine)	Dry	2A46-Q9-B90
	Wet	2A80-P-R
Malleable Castings		
Gates & Risers (Reinforced)	Dry	2A24-R-BF9
Masonry Blocks, Masonite, Concrete		
Portable Saws	Dry	6C24-R-BF9
Metallographic Specimens	Wet	2A80-N-RS
	Dry	2A80-P9-B90
Monel Metal		
Bar Stock	Dry	2A36-R9-B90
Bar Stock	Wet	2A46-R-RS
Tubing	Dry	2A60-S7-B90
Tubing & Small Sections	Wet	2A80-T-RS
Nickel		
Bar Stock	Wet	2A46-O-RS
	Dry	2A30-R9-B2S
Non-Ferrous Castings		
Gates - Risers	Dry	2A24-R-BF9
Gates - Risers	Wet	2A24-P-R
Paper		
Compressed Tubes	Dry	6C60-H6-RS
Pipe (Cast Iron)	Dry	2A30-R9-B90
(Reinforced)	Dry	2A24-R-BF9
Pipe - Steel		
General Purpose	Wet	2A46-O-RS
Heavy Wall	Dry	2A30-S7-B90
Reinforced	Dry	2A24-P-BF9
Pipe Ceramic		
Portable Saws (Reinforced)	Dry	6C24-R-BF9
Plastics	Dry	6C36-P9-B90
	Wet	6C46-N-R
Railroad		
Cut Off & Rail Slotting	Dry	2A36-R9-B90
(Reinforced)	Dry	2A24-T-BF9
Reamers		
Salvage Cut Off	Dry	2A36-R9-B90
(Reinforced)	Dry	2A24-R-BF9
Rolls - Iron - Chilled - Cast - Alloy		
Cut Off - Necks - Rotary	Wet	2A36-O-RS
Rolls - Steel		
Cut Off - Neck - Rotary	Wet	2A46-N-RS
Rubber		
Soft	Dry	6C30-Q9-B90
Rubber		
Hard	Dry	6C36-Q90-B90
Sand Cores		
Portable Saws - (Reinforced)	Dry	6C24-R-BF9
Steel Casting		
Cut Off (Reinforced Wheel)	Dry	2A24-R-BF9
Steel - Hardened	Wet	2A60-N-RS
	Dry	2A46-P9-B90
Steel - Soft		
Large Stock	Wet	2A46-O-RS
Medium Stock	Dry	2A36-R9-B90
Small Stock	Dry	2A36-S7-B90
Structural		
Channels - Angles, Etc.	Dry	2A30-R9-B90
Channels - Angles, Etc.	Wet	2A30-P-RS
Channels - Angles (Reinforced)	Dry	2A24-R-BF9
Steel - High Speed		
Tool and Reamer Salvage	Wet	2A46-N-RS
Tool and Reamer Salvage	Dry	2A54-P9-B90
Steel - Stainless (Free Machining)		
Billets & Forging	Wet	2A30-P-RS
Bar Stock	Dry	2A36-N9-B90
Bar Stock	Wet	2A46-O-RS
Bar Stock (Reinforced)	Dry	2A24-P-BF9
Steel - Stainless (Types 302, 303, 329, 443) (Non-Free Machining)		
Billets & Forgings	Dry	2A30-S7-B90
Bar Stock	Dry	2A30-N9-B90
Bar Stock	Wet	2A46-O-RS
Stellite	Dry	2A60-P9-B90
	Wet	2A54-Q-RS
Stone		
Cut Off & Slotting	Dry	6C36-O9-B90
Cut Off & Slotting (Reinforced)	Dry	6C24-R-BF9
Taps		
Cut Off & Salvage	Dry	2A54-P9-B90
Cut Off & Salvage	Wet	2A54-N-RS
Terra Cotta		
Reinforced Wheels	Dry	6C24-P-BF9
Non-Reinforced Wheels	Dry	6C36-O9-B90
Terrazzo	Dry	6C36-O9-B90
Tile		
Portable Saws (Reinforced)	Dry	6C24-R-BF9
(Non-Reinforced)	Dry	6C36-P9-B90
Titanium		
Blades, Billets, Bars	Wet	6C46-N-RS
	Wet	6C46-R9-B90
Tool Steel		
High Speed Steel (Hardened)	Dry	2A60-P9-B90
High Speed Steel (Hardened)	Wet	2A46-N-RR
Salvage	Dry	2A60-P9-B90
Salvage	Wet	2A54-N-RR
Transite		
Portable Saws	Dry	6C24-R-BF9
Portable Saws	Dry	6C24-P-BF9
Tubing		
Aluminum - Brass - Copper	Dry	2A30-P9-B90
Aluminum - Brass - Copper	Wet	6C80-R-R
Chrome Moly	Dry	2A30-Q9-B90
Chrome Moly	Wet	2A30-Q9-B90
Tubing (Continued)		
Steel - Heavy Wall	Dry	2A36-Q9-B90
Steel - Heavy Wall	Wet	2A54-O-RS
Steel - Thin Wall	Dry	2A60-S7-B90
Steel - Thin Wall	Wet	2A80-T-R
Stainless - Thin Wall	Wet	2A100-T-R
Stainless - Thin Wall	Dry	2A80-R9-B90
Galvanized	Wet	2A46-P-RS
Galvanized	Dry	2A54-O9-B90
Tungsten		
Bars, Rods, Wire	Wet	2A80-R-R
Valve Stems		
(Automobile)	Dry	2A36-T7-B90
Vasco Jet	Wet	2A80-M-RS
Zirconium	Wet	2A46-O-RS

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Cut-Off Wheel Recommendations

Horsepower Range:	10-15 HP	10-15 HP	20 HP & Over	20 HP & Over
Cross Sec. of Cut (Sq. In.)	Under 4	4 & Over	Under 8	8 & Over
APPLICATION				
Stainless Steel, Alloy Steel	AZ24-XBZ-55 or AK24-X11-BZ-55	AZ24-XBL3206-55 AK24-X11-BL3206-55	AZ24-ZBZ-55 AK24-ZBZ-55	AZ24-X-BZ-55 AK24-X11-BZ-55
Mild Steel, Cast Steel	AK24-X11-BZ-55	AK24-X11-BL3206-55	AK24-X11-BZ-55	AK24-X11-BL3206-55
Iron-Ductile, Gray Malleable	AK24-X11-BZ-55	AK24-X11-BL3206-55	AK24-ZBZ-55	AK24-X11-BZ-55
Brass, Bronze	AK24-X11-BZ-55	AK24-X11-BL3206-55	AK24-X11-BZ-55	AK24-X11-BL3206-55
Hot Cutting Ferrous Metals	AK24-X11-BZ-55	AK24-X11-BL3206-55	AK24-ZBZ-55	AK24-X11-BZ-55

HOT PRESS CUT-OFF

These reinforced hot pressed wheels are designed to be used in heavy duty cut-off operations where:

1. Cold press wheels do not meet the stiffness requirements.
2. Competitive hot press is being used.
3. Free-cutting, longer life wheels are needed.

These are recommended starting specifications. The side pattern may change based on application.

Optimizing - Cut-Off Wheels

SPECIFICATION: AK24-T9-B9

Abrasive:

1. H5AK} Will reduce burn, cut faster but shorter life
2. 10AK} Will reduce burn, cut faster but shorter life

Grit:

1. 20} Cooler cut and faster cut
2. 247} Will reduce burr, could increase burn

Grade:

1. R9} Faster cut, shorter life, less burn
2. V9} Slower cut, longer life, possible burn

Bond:

1. HP} Longer life but must have HP to cut

Side Finish:

1. Rough Sides} Eliminate burr and burn
2. Smooth Sides} Better finish

Cut-Off Wheels Dimensional Limits

Wheel OD	Minimum Thickness Limit (1)				Maximum Thickness (2) B2, B8 & BF9	*Thickness Tolerance (1) - 0.000 + (as shown)
	B2S, B8S	B2, B8	BF9S	BF9		
1	.049	0.020	N/A	N/A	3/16	+0.002
1½	.049	0.020	N/A	N/A	3/16	+0.002
2	.049	0.020	0.050	.035	3/16	+0.002
2½	.049	0.025	0.050	.035	3/16	+0.002
3	.049	0.025	0.050	.035	3/16	+0.002
3½	.049	0.031	0.050	.035	3/16	+0.002
4	.049	0.031	0.050	.035	3/16	+0.002
4½	.049	0.031	0.050	.050	3/16	+0.002
5	.049	0.031	0.050	.035	3/16	+0.002
6	.049	0.031	0.050	.035	3/16	+0.002
7	.049	0.031	0.052	.035	1/4	+0.003
8	.049	0.035	0.060	.040	1/4	+0.003
9	.062	0.040	0.075	.050	1/4	+0.003
10	.062	0.050	0.075	.060	1/4	+0.003
12	.062	0.062	0.095	.075	1/4	+0.004
14	.093	0.080	0.115	.093	3/8	+0.004
16	.093	0.093	0.125	.095	3/8	+0.004
18	.125	0.115	0.125	.125	3/8	+0.005
20	.125	0.125	0.125	.125	3/8	+0.005

Notes (1) Thinner wheels and/or tighter tolerances can be provided in some cases — contact Administrative Services. Wheel prices are increased substantially for these special wheels.
(2) A cut-off wheel cannot exceed this thickness. Thicker wheels are classified as Type 1 by the Grinding Wheel Safety Code.
**Applicable when Decimal Dimension is specified. See next page for Fractional Thickness Dimensions.*

Actual Versus Fractional Thickness Dimensions

	Actual Thickness Dimension	
Wheel Diameter	1 - 12	12 - 20
Fractional Thickness		
1/32	0.044 - 0.045	Not Available
1/16	0.077 - 0.079	Not Available
3/32	0.108 - 0.110	0.113 - 0.115
1/8	0.140 - 0.142	0.145 - 0.147
5/32	0.171 - 0.173	0.176 - 0.178
3/16	0.202 - 0.204	0.207 - 0.209
1/4 and Thicker	*Nominal ± 0.0015	*Nominal ± 0.0025

**Nominal means an exact conversion from fractional to decimal thickness, e.g., 1/4 = 0.250"*

Soft Grade Hardness Limits

Grit Size Range, All Grain Types	Soft Grade Hardness Limit by Bond Type for Operating Speed of:								
	12000 SFM			14200 SFM			16000 SFM		
	B2	B8	BF9	B2	B8	BF9	B2	B8	BF9
24 - 36	K	M	M	N	O	M	R	R	M
46 - 60	G	M	M	N	O	M	R	R	M
70 - 120	G	M	M	N	O	M	R	R	M
150 - 220	G	M	M	N	O	M	R	R	M

NOTE (1) Above table also applies to rough side suffix "S" wheels
(2) Softer grade B2 wheels may be available for use at these high speeds depending on wheel dimensions. Contact Administrative Services with specific request.

Limiting Wheel Dimensions

Dimensional Factor		Maximum Operating Speed		
		12000 SFM	14200 SFM	16000 SFM
Maximum OD		20	20	16
Minimum Thickness	B2, B8	Note (1)	1/16	1/16
	BF9, BF9S	Note (1)	Note (1)	Note (1)
Maximum ID		25% of OD	25% of OD	25% of OD

Note (1) Thickness limited by availability as shown in Dimensional Limits Table.

MIL 000234

Resin Wheel Recommendations

Cut-Off Wheel

Application	Specification	Application	Specification
Aluminum - Dry	AK36-R9-B9*	Malleable Iron, Unannealed: Low HP	AK24-R9-B9*
Aluminum Castings	AK24-T9-B9*	High HP	AK24-X7-BL3206-655
Brass Rod - Dry	AK24-T9-B9*	Manganese Steel: Low HP	AK24-R9-B9*
Brass Tubing - Dry	AK36-P9-B9*	High HP	AK24-T9-B9*
Brick - Portable Saws	CK24-R9-B9-2	Monel Metals	AK30-R9-B9*
Bronze, Hard	AK24-R9-B9*	Rails	AK247-R9-B9-088
Cast Iron	AK24-R9-B9*	Steel Castings: Swing Frame	AK24-T9-B9-088
Chilled Iron	AK30-P9-B9*	High HP	AK24-Y-BZ-55
Concrete Blocks	CK24-R9-B9-2	Steel, Soft: Low HP	AK24-T9-B9*
Copper - Gates & Risers	AK24-P9-B9*	High HP	AK24-X7-BL3206-655
Ductile Iron: Low HP	AK24-P9-B9*	Steel, Hardened: Low HP	AK30-R9-B9*
High HP	AK24-Y-BZ*	High HP	AK30-X7-BL3206-655
Malleable Iron, Annealed: Low HP	AK24-T9-B9*	Steel, Stainless: Low HP	AK24-R9-B9*
High HP	AK24-Y-BZ*	High HP	AK24-X7-BL3206*
		Titanium	CK80-P9-B9*

*Special marking must be added for wheels requiring reinforcement and for cut-off wheels requiring special side construction.

Hot Press Cut-Off Wheel

Horsepower Range	10-15 HP	10-15 HP	20 HP & Over	20 HP & Over
Cross-Section of Cut (sq. in.)	Under 4"	4" & Over	Under 8"	Over 8"
Application				
Stainless Steel	AZ24-X-BZ-55	AZ24-X7-BL3206-55	AZ24-Z-BZ-55	AZ24-Z-BZ-55
Alloy Steel	AK24-X11-BZ-55	AK24-X11-BL3206-55	AZ24-Z-BZ-55	AK24-X11-BZ-55
Mild Steel, Cast Steel	AK24-X11-BZ-55	AK24-X11-BL3206-55	AK24-X11-BZ-55	AK24-X11-BL3206-55
Iron Ductile, Gray Malleable	AK24-X11-BZ-55	AK24-X11-BL3206-55	AK24-Z-BZ-55	AK24-X11-BZ-55
Brass, Bronze	AK24-X11-BZ-55	AK24-X11-BL3206-55	AK24-X11-BZ-55	AK24-X11-BL3206-55
Hot Cutting Ferrous Metals	AK24-X11-BZ-55	AK24-X11-BL3206-55	AZ24-Z-BZ-55	AK24-X11-BZ-55

HOT PRESS CUT-OFF: These reinforced hot pressed wheels are designed to be used in heavy duty cut-off operations where:

1) Cold press wheels do not meet the stiffness requirements.
2) Competitive hot press wheels are being used.
3) Free-cutting, longer life wheels are needed.

These are recommended starting specifications. The side pattern may change based on application.

14

Cold Press Cut-Off Wheel

HP Range	10 HP or Less	10 HP or Less	11-19 HP	11-19 HP	20 HP & Over	20 HP & Over
Cross-Section of Cut (sq. in.)	Under 4"	Over 4"	Over 4"	Over 4"	Under 8"	Over 8"
Application						
Alloy Steel	AK24-R9-B9-188	AK24-P9-B9-188	AK24-T9-B9-188	AK24-R9-B9-188	AK24-V9-B9-188	AK24-T9-B9-188
Aluminum	AK24-R9-B9-188	AK24-P9-B9-188	AK24-T9-B9-188	AK24-R9-B9-188	AK24-V9-B9-188	AK24-T9-B9-188
Brass/Bronze	AK24-R9-B9-188	AK24-P9-B9-188	AK24-T9-B9-188	AK24-R9-B9-188	AK24-V9-B9-188	AK24-T9-B9-188
Carbon Steel	AK24-R9-B9-188	AK24-P9-B9-188	AK24-T9-B9-188	AK24-R9-B9-188	AK24-V9-B9-188	AK24-T9-B9-188
Cast Steel	AK24-R9-B9-188	AK24-P9-B9-188	AK24-T9-B9-188	AK24-R9-B9-188	AK24-V9-B9-188	AK24-T9-B9-188
Ductile Iron	AK24-R9-B9-188	AK24-P9-B9-188	AK24-T9-B9-188	AK24-R9-B9-188	AK24-V9-B9-188	AK24-T9-B9-188
Gray Iron	AK24-R9-B9-188	AK24-P9-B9-188	AK24-T9-B9-188	AK24-R9-B9-188	AK24-V9-B9-188	AK24-T9-B9-188
Malleable Iron	AK24-R9-B9-188	AK24-P9-B9-188	AK24-T9-B9-188	AK24-R9-B9-188	AK24-V9-B9-188	AK24-T9-B9-188
Mile Steel	AK24-T9-B9-188	AK24-R9-B9-188	AK24-V9-B9-188	AK24-T9-B9-188	AK24-X11-B328-188	AK24-V9-B9-188
Stainless Steel	AK24-R9-B9-188	AK24-P9-B9-188	AK24-T9-B9-188	AK24-R9-B9-188	AK24-V9-B9-188	AK24-T9-B9-188

*Reinforcement code may change based on application.
These are recommended starting specifications.

MIL 000235

Rubber Bond Wheels

Grain Type	Grit Size	Grit Size Combination	Grades Available	Structure	Bond
Cut-Off Wheels					
2A	24-220	Nominal or 3	L-N-O-P-Q-R-S-T-U-W	None	R-RS*
6C-5C	24-220	Nominal or 3	H-I-J-L-N-O-P-R-T	None	R-RS*
General Purpose - Tool Room					
2A-6C-5C	24-220	None	N-P-R	None	R
Centerless Regulating Wheels					
A	60-220	None	R-S-T	2	R
Centerless - Cylindrical - Surface Grinding					
2A-C4A	24-220	None	L-N-P-Q-R-T-U	None	R
6C-5C	24-100	None	L-N-P-Q-R-T-U	None	R

*NOTE: Subject to limitations of minimum thickness chart. *R = Smooth Sides **RS = Rough Sides*

Rubber Wheels Minimum Thickness Chart

Coarsest Grit — Softest Grade

Dia.	.005	.010	.015	.020	1/32	3/64	1/16	3/32	1/8	1/8T*	5/32	3/16	7/32	1/4	3/8
3/4 to 4	240-320 L-U	180-280 L-U	100-28- L-U	80-280 L-U	54-220 L-W 240-280 L-U	54-220 L-W 240-280 L-U	24-220 L-W 240-280 L-U	24-220 L-W 240-280 L-U	24-220 L-U 46-80 W			24 N-P,R	24 N-P,R	24 N-P,R	24 N-P,R
5		"	"	"	"	"	"	"	"			"	"	"	"
6			"	"	"	"	"	"	"			"	"	"	"
7				"	"	"	"	"	"			"	"	"	"
8					80-220 L-W 240-280 L-U	"	"	"	"			"	"	"	"
9					"	"	"	"	"			"	"	"	"
10					"	"	"	"	"			"	"	"	"
12					"	"	54-220 L-W 240-280 L-U	"	"			"	"	"	"
14							"	"	"	24-80 L-U	24-80 L-U	"	"	"	"
16								"	"	"	"	"	"	"	"
18								"	"	"	"	"	"	"	"
20									"	"	"	"	"	"	"
24										46-80 L-U	46-80 L-U	46-80 L-U	"	46-80 L-U	"
26										"	"	"	"	"	"
28-												"	"	"	"
30												"	"	"	"
32													"	"	"
34													"	"	"

Rough side wheels minimum thickness 1/32.
Diameter intermediate to those shown, same as next greater diameter
Thicknesses intermediate to those shown, same as next smaller thickness
**Tolernces for "1/8T" is .155- 170 available in 14 to 26 diameter, inclusive.*

SiC Cut-Off Grades Softer Than "L"

Dia.	1/32	3/64	1/16	3/32	1/8
12	60-H6	60-H6	60-H6	60-J6	60-J6
14		120-H6	60-H6	60-J6	60-J6
16			60-H6	60-J6	60-J6
18				60-J6	60-J6
20				60-J6	60-J6

Bond Types**

	BA	B320	BC	BF	BH	B254	B5	B9	BL 7227	B90	B291	E	BZ (HP)	BL 3206 (HP)	BL 6823 (HP)	BZ 1830 (HP)	B283	B303
General Purpose	X		X	X	X	X				X								
Cutoff		X						X					X	X	X	X	X	
Snagging			X	X	X	X												X
Fluting					X	X	X			X			X	X	X	X		
Roll Grinding		X									X	X						
Portable*		X	X	X	X	X												
Centerless			X	X	X	X			X	X	X							
NID/Type 2	X	X	X	X	X	X												X
Segments		X	X															

*With exceptions of Type 27, 27A, 28, 28A
**With exception of AZ product
NOTE: Specifications subject to approval by Carlisle Engineering

Available Abrasives

Description	Grit Size Available	Carlisle	Cincinnati
Aluminum Oxide			
Regular	12-30	*A	A
Semi-Friable	36-220	*2A	2A
Norton's 32A	24-220	11A	32A
White, Friable	16-220	*10A	9A
Pink, Friable	24-220	82A	12A
Alumina/Zirconia	14-46	20A	—
Alumina/Zirconia Premium	14-36	AZ	—
Silicon Carbide			
Regular, Black	12-220	*C	6C
Green	24-220	GC	5C
Mixture	24-220	FC	7C
Mixtures			
50/50 10A/A	16-220	*H5A	97A
50/50 C/A	16-220	*R5A	CA, C2A
50/50 C/10A	16-220	*E5A	—
35/65 20A/A	14-46	18A	—
35/65 20A/C	14-46	18C	—
50/50 20A/A	14-46	W5A	—
50/50 20A/C	14-46	W5C	—
60/40 20A/A	14-46	15A	—
60/40 20A/C	14-46	15C	—
50/50 82A/A	24-220	27A	

*Available in limited grit sizes with silane coating designated with "K" i.e. A silane coated = AK

High Performance Resin Bonds

BOND	USAGE RANGE	PURPOSE
BA	F-N	General purpose.
BC	L-Q	Range from A Bond
BF	P-R	(soft) to H Bond (hard).
BH	Q-S	
B254	P-W	High strength bonds
B5	R-V	used for both precision and snagging operations.
B320	F-O	Coolant resistant bond. Used for roll grinding and soft grade cut-off.
B9	N-V	Basic cold-pressed cut-off bond.
BL6823	X	Softest hot-pressed bond
BL3206	X	to hardest.
BZ	X-Z	
BZ1830	Z	
E	H-P	Shellac Bond

Carlisle Cut-Off Wheels — Cold Press

	SOFT	MEDIUM	HARD
Grade	K-P	P-V	V-X
Bond	B320	B9	B283

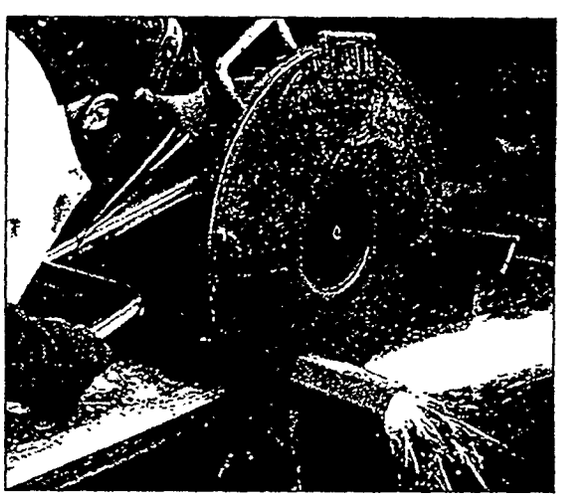
Carlisle Cut-Off Wheels — Hot Press

SOFTEST			HARDEST
BL6823	BL3206	*BZ243	BL1830

*Normal trial would be in BZ243 bond.

Wheel Reinforcement Code

Suffix Marketing	Fiberglass Placement
- 0 Cut Off Only	1 Full Diameter Inside
	2 Short Diameter Outside
- 1	1 Full Diameter Inside
- 2	2 Full Diameter Outside
- 3	2 Full Diameter Outside
	1 Full Diameter Inside
- 4	2 Full Diameter Inside
- 6 Cut Off Only	2 Full Diameter Inside
	2 Short Diameter Outside
- 8	3 Full Diameter Inside
-10 Cut Off Only	2 Short Diameter Outside



Cut-Off Wheel Side Roughness

Cut-Off wheel side roughness is shown in the suffix. If the wheels are reinforced, the following code markings are added to the reinforcement codes:

-66 smooth sides
-88 rough sides
-99 tefglas sides

For hot-pressed cut-off, the following indicates both 3 reinforcement and grooved sides unless another reinforcement pattern is specified:

-55 fine grooves
-77 coarse grooves

MIL 000238

1. We specialize in Type 1:
   A. Cut-off wheels non-reinforced .020" thru 1/4" to 20" diameter.
   B. Cut-off wheels reinforced 1/32" thru 3/8" to 20" diameter.
2. Wheels will be formulated to your specifications.
3. Reinforcement is available and recommended on severe job applications We reinforce wheels as thin as 1/32" thick at regular prices.
4. Maximum thickness limit on all wheels is 5/8" non-reinforced and 3/8 reinforced.
5. Cut-off wheels are normally stenciled (2-1/2" and larger) with blotters furnished loose.
6. Operating speeds higher than those shown in ANSI Safety Code B7.1 1978 will require a special speed certificate.
7. Manufacturing conditions under which special price must be charged:
   A. All wheels less than .020 thickness regardless of diameter.
   B. Any wheel made below our manufacturing limits charge.
8. All popular hole sizes available as well as: 20MM, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12. Special holes for drive pin mounting available on request at no extra charge.
9. Metal centers available on wheels .093 or thicker. (Note: If universal center is required, wheel must be .109 or thicker.)
10. Precision balance wheels do not require an extra charge.
11. Rough sides (screen sides) are available. We do not offer "phonograph" sides. Saw gummer sides must be specified.
12. Thin wheels (.049 or thinner) cannot be rough sided at published prices.
13. Close thickness tolerance cannot be held on rough sided wheels.

NOTE: Phonograph sides are available only on Hot Press Wheels.

Grade

Use as hard a grade as possible to get maximum wheel life. Start with a softer grade (M-O) on hard materials (e.g. steel) and harder grades (P-Q) on softer materials (e.g. brass).

Reinforced Wheel - Rough Side

The fiber glass reinforcement is placed on both sides of BF9 cut-off wheels. In some specifications, it is possible to put a single sheet of fiber glass inside the wheel and provide rough sides. Contact Application Services to determine if this can be done for each specific application. Such wheels will also be designated by the suffix S.

Example: 2A46-P7-BF9S or R5A46-P7-B320-88

Structure

Structure changes permit fine tuning of a grade for an application. A high structure number wheel (e.g. 9) contains less abrasive grain than a low structure number wheel (e.g. 5). The less dense, high structure number wheel will act slightly softer than a lower structure number wheel of the same hardness grade.

A 7-structure wheel should be selected for all starting specifications. The hardness grade should be increased until the wheel acts too hard. A 9-structure wheel in the "too hard" grade, or a 5-structure wheel in the next softer grade provide between grade hardness changes.

Example: If a 2A60-P7-BB8 is too hard, and a 2A60-O7-B8 was too soft, try either: 2A60-P9-B8 or 2A60-O5-B8.

Bond Type

B2 — a softer acting bond available in a broad range of grades — especially useful on heat sensitive materials. Available in K and harder grades, 7 and 9-structure.

B8 — a durable bond for high production operations. Available in M-W hardness grades, 5, 7 and 9-structure.

BF9 — a fiber glass reinforced product similar in performance to B8. It is used where high strength is required. Available in M-W hardness grades, 5, 7 and 9-structure.

B8 and BF9 should be substituted grade for grade for B2 or competitive wheels.

Rough Sides

Rough sides are available on B90-B320 and B8 cut-off wheels. the rough sides help to reduce drag and friction from side rubbing. Rough sides are designated by the suffix S.
Example: 2A46-P7-B8S.

Rough sides are limited by wheel size and thickness.

Rough Side Dimensional Limits	
Wheel OD	Minimum Thickness For Rough Side
1 - 12"	1/32" (1)
14 - 20"	1/16" (1)

Note (1) Thickness also limited by availability as shown in Dimensional Limits Table.

Rough Side Cut-Off Wheels*

BF-9 — The fiber glass reinforcement is placed on both sides of BF9 cut-off wheels. In some specifications, it is possible to put a single sheet of fiber glass inside the wheel and provide rough sides. Such wheels will also be designated by the suffix S. Example: 2A46-P7-BF9S.

B90-B320 — Rough sides are available on B90-B320 and B8 cut-off wheels. The rough sides help to reduce drag and friction from side rubbing. Rough sides are designated by the suffix S or 88. Example: 2A46-P7-B8S.

Safety — Wheel Orders

Cut-off wheels are used on special, well-guarded machines. In recognition of this, cut-off wheels are permitted by the ANSI B7.1 to run at special higher operating speeds. A wheel of a size similar to a cut-off wheel may be used in another type of grinding operation, e.g. flute grinding. Such a wheel is classed as a Type 1 wheel and must be proof speed tested at a higher level than a cut-off wheel. It is imperative that wheel orders show the correct type of wheel: "cut-off" for cut-off wheels and Type 1 for thin wheels used on other grinders.

**See dimensional limits table for minimal thickness.*

Dimensional and Operating Speed Limits

The following tables designate the standard available dimensional limits and the limits of operating speed by dimensions and cut-off wheel specification. Exceptions to these limits can sometimes be made as shown in the table footnotes. In addition, one other exception should be noted:

Wheel Thickness and ID Size

The tables show that the thickness and ID sizes of cut-off wheels are limited relative to the OD size. These limitations are specified by the ANSI B7.1. Wheels exceeding these limits are classified as Type 1 wheels. Type 1 wheels are not normally operated at cut-off wheel speeds. However, Application Services may be able to authorize the use of specific Type 1 wheel specifications at cut-off wheel speeds. These wheels will be identified with the suffix E indicating that they have been approved for use at a special speed.

Machine & Wheel Data

All cut-off wheels are Type 1. They are furnished for both wet or dry operations in the various organic bond systems (rubber, resinoid or shellac). Most production type jobs use rubber wheels on wet applications and resinoid wheels on dry applications, although some rubber wheels are also used dry. Shellac wheels are generally supplied in relatively small sizes, for either wet or dry applications, predominantly of the tool-room type category where extreme versatility and quality of cut are of major consideration. See Bond Types.

Typical Machine Manufacturers

Approved Devices	Delta	Savage
Campbell	deSanno (Radiac)	Stone
Carborundum	Emerson	Ty-Sa-Man
Continental	Everett	Waber
Curtis-Toledo	Max	Wallace

Approved Devices Co.

Machine/Model	Wheel Size*	Spindle Speed/RPM
Cut-Off Machine—Dry or Wet	(6, 7 or 8) x 1/16 x 1/2	4000

Campbell Machine Div., American Chain & Cable Co., Inc. Bridgeport, CT (W.J. Savage, Knoxville, TN)

Machine/Model	Wheel Size*	Spindle Speed/RPM
Abrasive Cutting Machines		
No. 15—Dry-Bar Type	12 x 3/32 x 1	5200
15—Wet-Bar Type	14 x 3/32 x 1	2600
20—Dry-Bar Type	16 x 1/8 x 1	4200
28—Dry-Bar Type	18 x 1/8 x 1	2450
202, 203, 212, 213 Wet-Bar Type	16 x (1/16 x to 1/8) x 1	2450
223, 265—Wet-Bar Type	(16 or 18) x (1/16 thru 1/8) x 1	2150
302—Wet-Horizontal	(16 or 18) x (1/16 thru 1/8) x 1	1200 & 1800
342—Wet-Horizontal	20 x 1/8 x 1	1200
3240—Wet-Horizontal	20 x 1/8 x 1	1200
401—Wet-Cutamatic	20 x 1/8 x 1	1400
406—Wet-Cutamatic	20 x 1/8 x 1	1400
425—Wet Cutamatic	18 x 1/8 x 1	1800
460—Wet-Semi Automatic	20 x 1/8 x 1	1400
470—Wet-Automatic	20 x 1/8 x 1	1400
476—Automatic-CUTAMATIC	20 x 1/8 x 1	1400
480—Wet-Semi Automatic	26 x 5/32 x 1	1200
1—Wet-HUDORKUT	14 x (1/32 thru 3/32) x 1	1800
2—Wet-HUDORKUT	16 x (1/32 thru 1/8) x 1	1400

Campbell Machine Div., (cont'd)

Machine/Model	Wheel Size*	Spindle Speed/RPM
509—Wet-Rotary	20 x 1/8 x 1	1400
514—Wet-Rotary	20 x 1/8 x 1	1400
CUTAMATIC		
No. 64 Wet	(16 or 18) x 1/8 x 1	2150
102A—Wet	20 x 1/8 x 1	1450
270—Wet-Bar Type	(16 or 18) x (1/16 thru 1/8) x 1	2150
290—Dry-Wire Rope	16 x (1/8 thru 3/16) x 1	2150
364—Wet-Horizontal	26 x 5/32 x 1	1000
481—Wet-Semi Automatic	26 x 5/32 x 1	1000
612—Wet-Semi Automatic	34 x 7/32 x 1	840
930—Wet-Rotary	30 x 7/32 x 1	1400
SEVER-All Machines		
1A—Dry-Bar Type	12 x 3/32 x 1	3450
2B—Dry-Bar Type	20 x 1/8 x 1	2150
3A—Dry-Bar Type	26 x 7/32 x 1	1700
22A—Dry-Angle	20 x 1/8 x 1	2150
52A—Dry-Rotary	20 x 1/8 x 1	2150

The Carborundum Co., Niagara Falls, N.Y.

Machine/Model	Wheel Size*	Spindle Speed/RPM
Machine/Model	Wheel Size*	MOS/RPM
Vibratory Cut-Off		
VB600 — 50HP	26 x 3/16 x 1	1760
VERTIARC V10-75HP	36 x 7/32 x 6	1400
VERTIARC V14-150HP	38 x 3/8 x 6	750
Orbital Cut-Off		
RCS-24" — 100HP	34 x 7/32 x 6	900
RCS-30" — 150HP	48 x 3/8 x 6	750
RCS-34" — 150HP		
Horizontal Plate Saws		
144 Series — 20HP	20 x 1/8 x 1 1/4	1900
111-211 Series — 50HP	34 x 7/32 x 1 11/16	1400
122-222 Series — 75HP	36 x 7/32 x 2 3/8	1400
133-233 Series — 150HP	48 x 3/8 x 3 1/4	750

Continental Machine Tool Co., Irvine, CA

Machine/Model	Wheel Size*	Spindle Speed/RPM
CONTINENTAL ULTICUT		
34W75-75HP — 34" Wet	34 x .240 x 1	1000
26W50-50HP — 26" Wet	26 x .180 x 1	1350
22W20-20HP — 22" Wet semi-automatic (also made complete automatic)	22 x .165 x 1	1550
DS2420-20HP — 24" dry manual feed control, miter/straight	24 x .170 x 1	2000
WS2420-20HP — 24" wet manual power feed, totally automatic	24 x .170 x 1	1450

*Wheel Shape — Type 1

MIL 000241

Curtis-Toledo, A Wyle Company

(Formerly Toledo-Beaver) St. Louis, MO

Machine/Model	Wheel Size*	Spindle Speed/RPM
No. 151	12 x 1/8 x 1	4000
	14 x 3/32 x 1	2800
		2800
	14 x 1/8 x 1	2300
	16 x 3/32 x 1	1530
	16 x 1/8 x 1	
	18 x 1/8 x 1	
	20 x 5/32 x 1	
No. 100, 110, 120		
Speed Cut—Dry	11 x 1/16 x 1	4060
No. 14 S.C.—Wet or Dry	14 x 3/32 x 1	2875
No. 14 S.C.—Dry	14 x 1/8 x 1	2875
No. 16 S.C.—Wet or Dry	16 x 3/32 x 1	2875
No. 16 S.C.—Dry	16 x 3/32 x 1	2875
No. 16 S.C.—Dry	16 x 1/8 x 1	2875
No. 20 S.C.—Wet or Dry	18 x 1/8 x 1	2300
NO. 20 S.C.—Dry	18 x 1/8 x 1	2300
No. 20 S.C.—Dry	20 x 1/8 x 1	2300
No. 20 S.C.—Wet	20 x 1/8 x 1	1470

A.P. deSanno & Son, Inc. Phoenixville, PA

Machine/Model	Wheel Size*	Spindle Speed/RPM
Type C—Dry	12 x 3/32 x 1	5200
	14 x 3/32 x 1	4300
Type F—Dry	10 x 3/32 x 5/8	5200
Type G—Wet	10 x (1/16, 3/32 or 1/8) x 5/8	2050
Types J & JH—Wet	18 x (1/16, 3/32 or 1/8) x 1	2050
	20 x (1/16, 3/32 or 1/8) x 1	2050
Type JOAH—Wet	20 x (3/32 or 1/8) x 1	1600
Type K & KH—Wet	16 x (1/16, 3/32 or 1/8) x 1	2050
Dry	14 x (3/32 or 1/8) x 1	4100
Types L & M—Dry	12 x (1/16, 3/32 or 1/8) x 7/8	5200
Type N—Wet	14 x (1/16, 3/32 or 1/8) x 7/8	2050
Type N16—Wet	16 x (1/16, 3/32 or 1/8) x 7/8	2050
Type N16-FA—Wet	16 x 3/32 x 7/8	2050
Type P—Dry	18 x 1/8 x 1	2500
RADIAC Machines		
GR-200 (Manual)—Wet	10 x 1/16 x 1	2050
	12 x 3/32 x 3/4	2050
GR-201 (Semi-Automatic)—Dry	12 x 3/32 x 1 1/4	4300
GR-203 (Fully-Automatic)—Wet	14 x 3/32 x 1	2700

A.P. deSanno & Son, Inc. (cont'd.)

Machine/Model	Wheel Size*	Spindle Speed/RPM
GR-75 (Fully-Automatic) travelling head)—Dry	14 x 3/32 x 1 1/4	4300
GR-601 (Fully-Automatic) work rotating machine)—Dry	16 x 3/32 x 1	3600
JR-400 (Manual)—Wet or Dry	18 x 1/8 x 1	2050
JR-401 (Semi-Automatic)—Wet or Dry	20 x 1/8 x 1	2050
JR-403 (Fully-Automatic)—Wet or Dry	22 x 1/8 x 1	2050
CTR-501 (Semi-Automatic)—Wet	24 x 5/32 x 1	1500
CTR-503 (Fully-Automatic)—Wet	26 x 3/16 x 1	
Single speed motor		1500
Variable speed motor		variable
BR375 FA (Fully-Automatic) travelling head—Wet	14 x 3/32 x 3/4	2700
BR276SA (Semi-Automatic) bearing cap—Dry	18 x 1/8 x 1	3600
TW-100 2HP, 1 or 3 phase capacity	7 x .020 x (1/2 thru 1/4)	3450
1" solids or 2" tubing—Wet	10 x .030 x (1/2 thru 1/4)	
deSCal Machines		
DM—Dry	12 x 1/8 x 1	3400
DJ-DJA—Dry	16 x 1/8 x 1	2950
DS-DSA-DTG—Dry	20 x 1/8 x 1	2200

NOTE: All models K, KH, JOAH, J and JH made prior to 1964 are equipped with 7/8" diameter spindles.

Emerson Electric Co., Special Products Division, St. Louis, MO

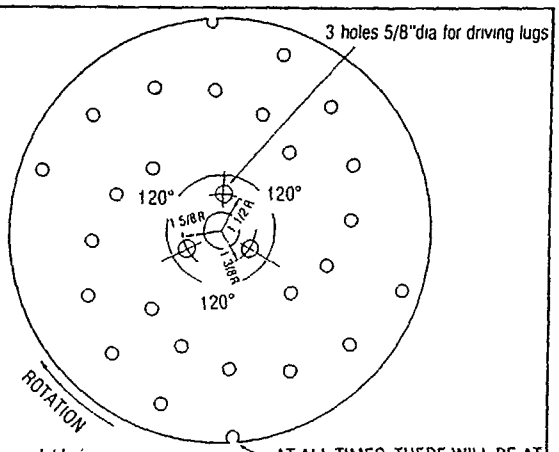
Machine/Model	Wheel Size*	Spindle Speed/RPM
Abrasive Cut-Off Machines—Dry	16 x (3/32 thru 3/16) x 1	3100
	10 x (3/32 x 1/8) x 5/8	4750
	8 x (3/32 thru 1/8) x 5/8	4750

Everett Industries, Inc., Warren, OH

Machine/Model	Wheel Size*	Spindle Speed/RPM
Cut-off Machines-Dry-30HP	26 x 7/32 x 1	Type 1

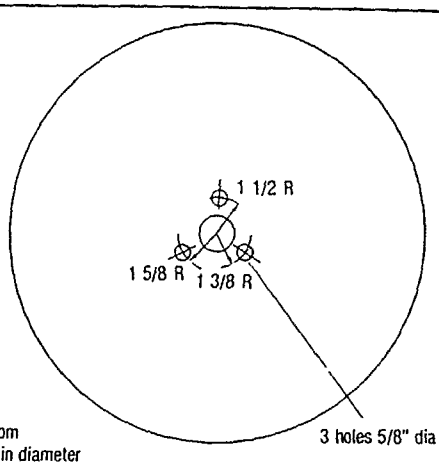
MIL 000242

Arbor Holes



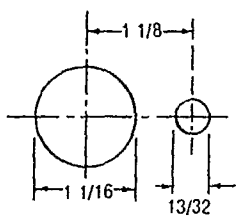
This type is available in
diameters from 12" through 26"
thickness from 3/32" through 1/8"
bore from 7/8" through 1 1/2"
subject to grade and grain size limitations.
RUBBER BOND ONLY

AT ALL TIMES, THERE WILL BE AT LEAST 2 HOLES BREAKING THROUGH AT PERIPHERY



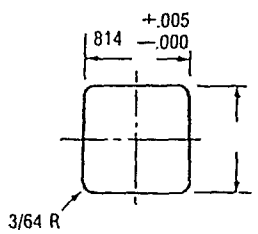
available from
10" to 20" in diameter
.045" to 1/8" in thickness
bore 7/8" to 1 1/2"
subject to grade and grain size limitations
RUBBER BOND AVAILABLE
RESIN BOND ON SPECIAL ORDER ONLY

E-23



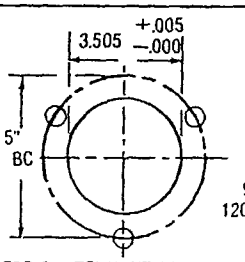
FOR TRI-LINE, CLIPPER MACHINES

E-24



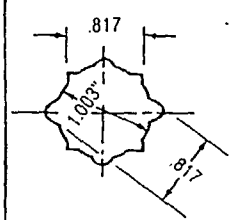
FOR MALL, WAPPAT MACHINES

E-25



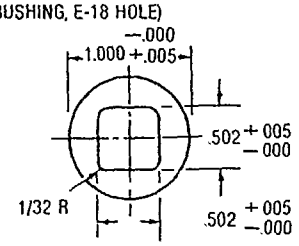
FOR O.H. TENNANT CO. MACHINES

E-26 UNIVERSAL ARBOR HOLE



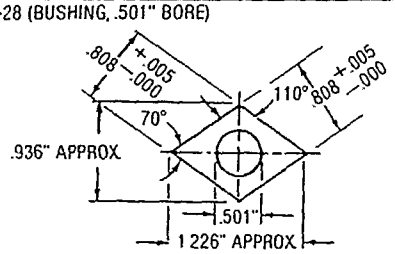
USED ON SKILSAW (E-11), THOR (E-11), MALL (E-24), WAPPAT (E 24) AND OTHER MACHINES HAVING 1" ROUND ARBORS. WHEN USED WITH EXTRA BUSHINGS, CAN ALSO BE USED ON MALL (E-10) AND ON OTHER MACHINES SUCH AS THE SPEEDMATIC HAVING 1/2" OR 5/8" ROUND ARBORS (E-27, E-28, E-29)

E-27 (BUSHING, E-18 HOLE)



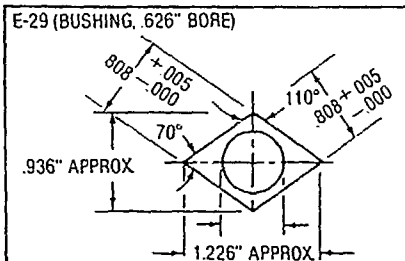
CAN BE USED ON MALL MACHINES

E-28 (BUSHING, .501" BORE)



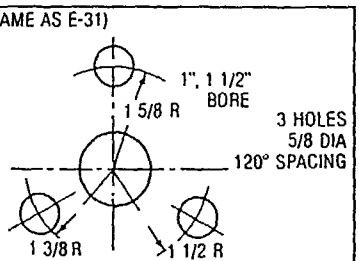
CAN BE USED ON SPEEDMATICS

E-29 (BUSHING, .626" BORE)



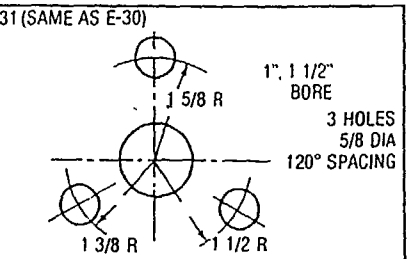
CAN BE USED ON SPEEDMATICS

E-30 (SAME AS E-31)



FOR CAMPBELL MACHINES

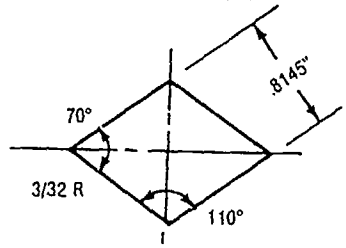
E-31 (SAME AS E-30)



FOR CAMPBELL MACHINES

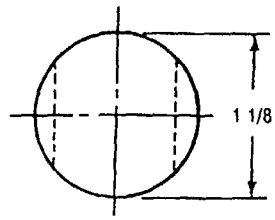
14

E-11



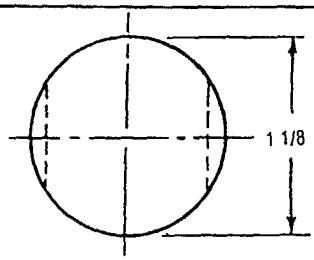
FOR SKILSAW, THOR MACHINES

E-12



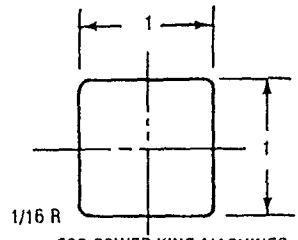
REPLACES SHAPE SHOWN BY DOTTED LINES FOR BLACK & DECKER MACHINES

E-13



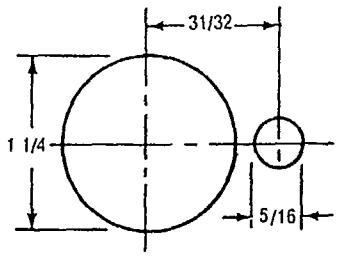
REPLACES SHAPE SHOWN BY DOTTED LINES FOR BLACK & DECKER MACHINES

E-14

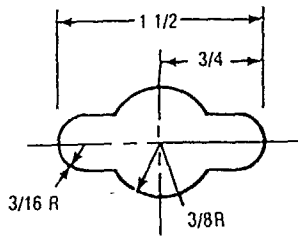


FOR POWER KING MACHINES

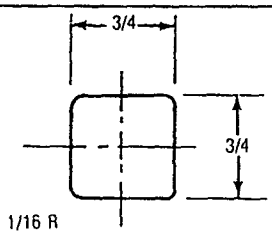
E-15



E-16

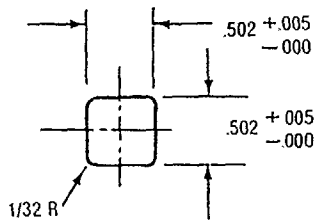


E-17



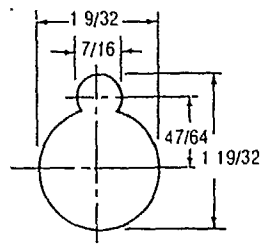
FOR POWER KING, U.S. ELECTRIC MACHINES

E-18



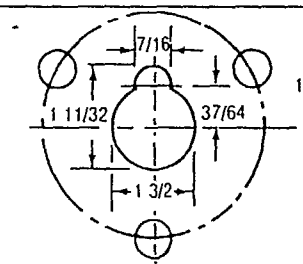
FOR THOR, MALL MACHINES

E-19



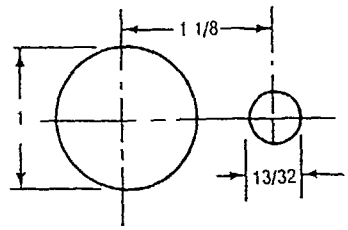
FOR CONCUT MACHINES

E-20



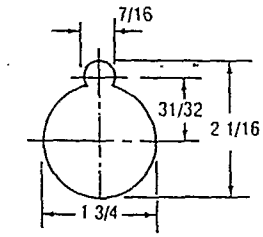
FOR CUTCRETE MACHINES

E-21



FOR CLIPPER MACHINES

E-22



FOR FELKER MACHINES

Principles Of Abrasive Cut-Off Wheels

Abrasive Cut-Off Machines can be operated dry or wet, low or high speed, and either manual operated or automatic. Machines are manufactured with an oscillating or reciprocating wheel head or special work holding fixture that rotates the work while cutting, all the way down to the more common general purpose, chopper type machine. Each type has its advantages and field of application.

The majority of materials used in the construction trades and manufacturing can be satisfactorily cut off with abrasive wheels. more wheels are used to cut metals than other materials. However, natural stone, ceramics, tile, brick, plastics, insulating materials, glass, concrete blocks and reinforced concrete, etc., are also cut with abrasive cut-off wheels.

The maximum wheel speeds shown in Table 20 of the American National Standards Institute Safety Code (A.N.S.I.) B7.1 for organic cut-off wheels larger than 16" diameter are 9500 SFPM to 14,200 SFPM, including reinforced organic wheels. For wheels 16" diameter and smaller, the maximum wheel speeds for organic cut-off wheels, including reinforced organic, are 9500 SFPM to 16,000 SFPM.

For wet cutting off operations, the wheel is generally operated much slower, approximately 10,000 SFPM, to cool the work more effectively. The wheel operating at high speeds throws an air blast that blows the cutting fluid away from the point of contact.

When the work requires submerged cutting, the wheels operate at speeds between 6000 and 10,000 SFPM.

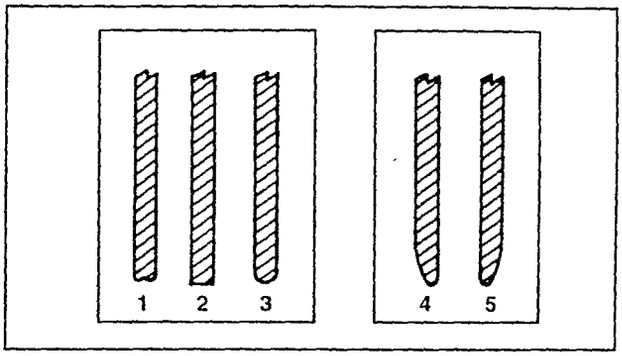
Machines with an oscillating spindle are usually operated wet. The oscillating movement of the wheel greatly increases the size of work that a machine can handle, making it possible to cut bars and tubes up to 6" diameter.

Machines equipped for rotation of work can cut larger diameter work with smaller diameter wheels than most other types of cut-off machines and can wear a wheel to a smaller diameter stub. the reduced arc of contact decreases wheel life. Wheels for cut-off machines are available in two bond types — resin and rubber.

Rubber bond cut-off wheels are generally used wet. When used dry, the bond softens under the heat of the cut and breaks down rapidly, and at the same time, gives off the obnoxious odor of burning rubber. The odor is greatly reduced and wheel life increased when used wet.

Most dry cutting off operations are done with a resin bond wheel. However, resin bond can be used either wet or dry. If coolant is used, it must be applied to the point of contact between the wheel and the work, and equally on both sides of the wheel to obtain a straight cut.

Note sketch showing wear pattern of cut-off wheel faces and the effect of coolant application.
1, 2, and 3 show a normal wear pattern of wheel faces



that have an equal amount of coolant on each side and point of contact, and will make a straight cut. Sketch number 4 and 5 shows a wheel face caused by an unequal amount of coolant having been applied to the sides of the wheel (greater wear on the bevel side, which is the side with least coolant). This wheel cannot cut straight and is subject to more frequent breakage than wheels that wear like shapes 1, 2, and 3. The concave face on Sketch #1 is the result of an insufficient volume of cutting fluid, or grade of wheel is too had. A small concave face is satisfactory and will not cause breakage, and will make a straight cut. However, if concave becomes excessive, it will be necessary to use a softer grade of wheel to eliminate it.

Two types of abrasive grains are used to cut the majority of materials, silicon carbide and aluminum oxide. Silicon carbide is generally recommended for non-ferrous metals, glass, ceramics, plastics, refractories, etc., and aluminum oxide for ferrous metals. To select a grade of wheel to cut various materials, refer to the General Starting Recommendation chart. Soft wheels give the highest quality cuts. They cut faster, but don't last as long as harder wheels.

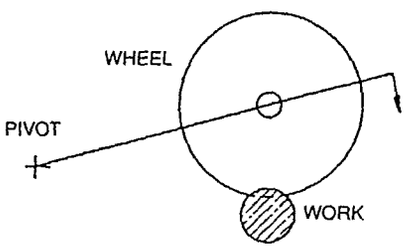
For machines with less than 5 horsepower, use soft or medium grade wheels.

For oscillating spindle machines and rotary machines where the work can be rotated as it is being cut, use medium to hard grade wheels. Use a coarse grit wheel to cut solids. Use finer grit wheels to cut tubing or solids to produce less burr. Always use wheels that wear to a square or concave face, not to a face that is pointed or convex.

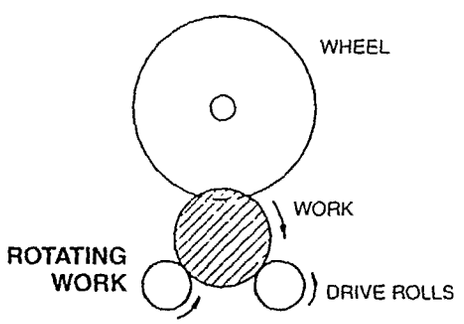
Smooth sided wheels are used in most general cut-off work where the material does not have a tendency to load the wheel, or where there are machining operations following the cut-off operation.

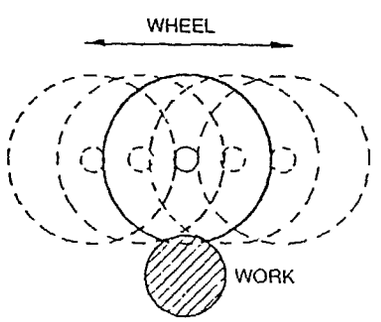
Rough sided wheels are recommended when the cut-off operation requires a minimum burr, or no burn, or on heavy sections, and deep cuts, and the material has a tendency to load or bind the wheel. Rough sided wheels are also used for brass and copper, soft bronze, steel cable, aluminum, carbon and soft steel, and similar materials.

Some rubber wheels are made with a series of holes thru the wheel to help carry cutting fluid into the cut, cooling the part more than a non-perforated wheel would. These holes are arranged in a spiral from the flange diameter to the periphery and are located so that 2 holes are breaking thru the periphery of the wheel at one time. This gives an intermittent cut which helps the wheel to break down and prevent load, increasing the wheel's ability to cut cooler and freer when cutting heavy sections and large diameter bars, etc.

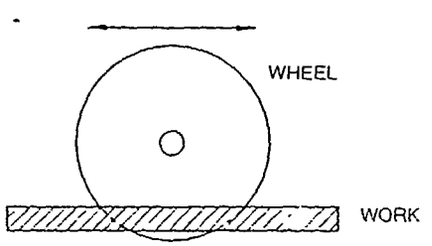


CHOP STROKE





OSCILLATING WHEELHEAD

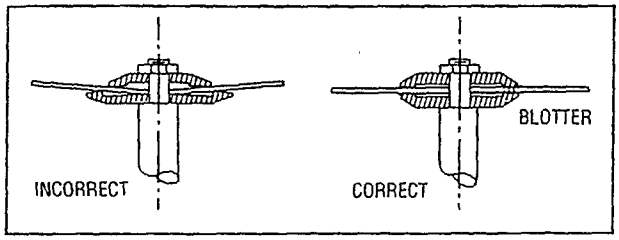


TRAVERSE

MIL 000246

Common Cut-Off Wheel Problems

1. Angular Cuts and Wheel Breakage
   A. Improper mounting of wheel.

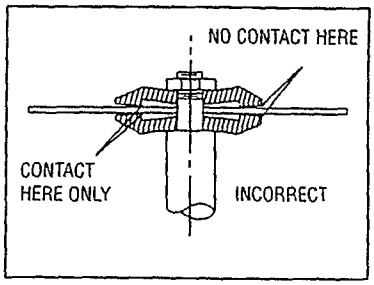


   B. Work improperly clamped
   Inadequate clamping of work will allow movement of the work while wheel is in the cut.
   C. Wheel vibration from worn spindle bearings.
   D. Excessive wheel feed into work.
   E. Belt slippage or not enough power. Wheel slows or stalls in cut.
2. Burning of work — wheel chipping on edge.
3. Excessive burr.
4. Wheel wears on 1 side — will not cut straight.
5. Excessive wheel wear
   A. Grade of wheel too hard, causing burning out of bond.
   B. Grade of wheel too soft, causing excessive breakdown.
   C. Inadequate coolant supply.

Corrective Action

1.
   A. Check flanges, they should be flat and the same diameter, and recessed to provide equal and opposite bearing areas.

Excessive tightening of the spindle nut may have bent the flanges causing wheel breakage.



   B. The work should be clamped on both sides of the cut to prevent movement of the work while cutting.
   C. This vibration will break wheels — replace spindle bearings.
   D. This happens more on machines with power feed than manual feed. Reduce feed rate to within metal removal capability of wheel.
   E. Check belts and tighten, if needed. Increase H.P. or take lighter cuts.
2. Wheel too hard — use softer grade.
3. Use finer grain and softer wheel.
4. Unequal distribution of coolant on sides of wheel.
5.
   A. Use softer grade of wheel.
   B. Use harder grade of wheel.
   C. Increase volume of coolant.

MIL 000247

15 Flute Grinding

Recommended Starting Grades For Flute Grinding

Wheel Dia. (mm)	Thickness	End Use	General Specifications	HERTLINE	DA Recommendation
>100<200	Variable	Straight Fluting Taps<8mm	AK120-V11-B5	AK100-V11-BL7331	DA100-V11-B5
	Variable	>8mm<13mm	AK120-V11-B5	AK100-V11-BL7331	DA100-V11-B5
	Variable	>13mm	AK100-V11-B5	AK100-V11-B5	DA100-V11-B5
	Variable	Straight Fluting Reamers	AK120-V11-B5	AK100-V11-BL7331	DA100-V11-B5
>200 MM	Variable	Straight Fluting Extra Long Reamers & Taps	AK100-V11-B5	AK100-V11-BL7331	DA100-V11-B5
>300<500	Variable	Fluting Centre Drills	AK100-S8-BH	AK100-X11-BZ	DA100-X11-BL3206
	Variable	Fluting Short End Mills	AK100-S8-BH	AK100-X11-BZ	DA100-X11-BL3206
	Variable	Fluting Router Bits (Small)	AK100-V11-B5	AK100-V11-BL7331	DA100-V11-B5
	Variable	Fluting Router Bits (Large)	AK100-Q8-BH	AK100-R8-BH	DA100-S8-BH
<300	<2	Spiral Fluting of Drills & Taps	AK150-R8-BH	AK180-S8-BH	DA150-S8-BH
	>2<3.5		AK120-Q8-BH	AK120-R8-BH	DA120-S8-BH
	>3.5<4.75		AK120-Q8-BH	AK120-R8-BH	DA120-S8-BH
	>4.75		AK120-Q8-BH	AK120-Q8-BH	DA120-R8-BH
>300	>2<4.75	Spiral Fluting of Soft End Mills	AK120-P8-BF	AK120-S8-BF	DA120-S8-BH
	>4.75		AK120-P8-BF	AK120-S8-BH	DA120-S8-BH
	>2<4.75	Spiral Fluting of Tough Steel End Mills	AK100-R8-BH	AK100-X11-BZ	DA100-X11-BL3206
	>4.75		AK100-S8-BH	AK100-X11-BZ	DA100-X11-BL3206
>300<500	<4.75	Spiral Fluting of Drills & Taps	AK120-P8-BF	AK120-Q8-BH	DA120-Q8-BH
	>4.75		AK120-Q8-BH	AK120-R8-BH	DA120-R8-BH
	<4.75	Spiral Fluting of End Mills	AK120-P8-BF	AK120-R8-BH	DA120-S8-BH
	>4.75		AK120-S8-BH	AK100-X11-BH	DA100-X11-BL3206
	>4.75	End Mills - Soft Steels	AK60-S8-BH	AK54-S8-BH	DA54-S8-BH
>300<500	<6mm	Gun Pointing Spiral Taps	AK150-Q8-BH	AK120-S8-BH	DA120-S8-BH
	>6mm		AK100-Q8-BH	AK80-S8-BH	DA120-S8-BH
	Variable	Gun Pointing Straight Taps	AK120-V11-B5	AK100-V11-BL7331	DA100-V11-BL7331
	Variable	Slotting Long Drills 25mm	AK100-S8-BH	AK100-S8-BH	DA100-T8-B5
	Variable	Slotting Small Taps - Reamers	AK120-V11-B5	AK100-V11-BL7331	DA100-V11-B5
	<25mm	Drill Step	AK80-P8-BF	AK100-Q8-BF	DA100-R8-BH
	<16mm	Gashing End Mills	AK100-S8-BH	AK100-X11-BZ	DA100-X11-BL3206

BH Products

BH products are available within the following limits:

Maximum diameter 20"
Maximum thickness 1/2"

Minimum thickness same on cut-off wheels

Abrasive types 2A, 97A, 9A, 12A, 6C, C2A, 29A

Purpose	Bond System	Grit Size	Available Grades	Structure Preferred	Structure Alternate
Thread & others	BH	24-240	P-X	7	5, 9
Drill points or spiral flutes	BHJ	36-180	N-T	7	9
Straight tap flutes or spiral flutes	BHR	46-240	P-X	7	(none)
All spiral flutes	BHQ	36-180	M-X	7	(none)

Machine And Wheel Data

Machine/Model/ Application	Wheel Size	Wheel Grade
Tap Shank Squaring Maching SQ-100	Clearance 30 x 1 x 12 (Soft Steel)	82A80-Q8-BH 82A54-T8-B5
SQ-150	Clearance 30 x (Various) x 12	82A54-T8-B5
Tap Chamfer Grinder TC-100, TC-200	Clearance 14 x (Various) x 5	2A80-T8-B5
Tang Grinder TG-150, TG-170	Clearance 30 x (3/4 &1) x 12	82A54-R8-BH
	Fluting 15 x .350 x 8	82A100-R8-BH
Subland Drill Grinder SL-100	Clearance 8 x 1/4 x 1-3/4 (1/4 tapered to 1/8)	9A80-K6-VRW
Clearance Grinder (Drill Margins) CG-8	Clearance 8 x (1/8, 5/32, 3/16) x 1-1/4	2A100-K6-VRW
CG-10	Clearance 10 x (3/16, 1/4, 3/8, 1/2) x 1-1/4	2A100-R-R
CG-12	Clearance 12 x (3/8, 1/2, 5/8, 3/4) x 3	2A100-R-R
CG-80	Fluting 8 x (Various) x 1-3/4	2A100-T8-B5
Drill & Countersink Relief Grinder OCD-50	Clearance 20 x 3/8 x 5	2A80-P-R
OCD-150	20 x 7/8 x 5 (Recess 1/Side)	2A80-R-R
Center Drill Grinder CD-312E	Fluting 12 x (Various) x 8	82A100-R8-BH
CD-318E, CD-418	Fluting 18 x (Various) x 8	82A100-R8-BH
Drill Point Grinder DPG-8	8 x 3/4 x 1-1/4	
	8 x 2-1/4 x 5-1/8 Cup Wheel for soft steel	12A80-J6-VRW 12A54-I6-VRW
PG-80	8 x 2-1/4 x 5-1/8 Cup Wheel	2A220-O5-BC
Step & Radial Relief Grinder SD-100	Clearance 16 x 1 x 5	H5A80-P8-BF
	16 x 1-1/2 x 5 R 1/S 7-1/4 X 1/2	H5A80-P8-BF
	16 X 2 X 5 R 2/S 7-1/4 X 1/2	H5A54-P8-BF
Router Bit Grinder RBR-100	Clearance 14 x 1 x 5	2A80-P-R

Machine/Model/ Application	Wheel Size	Wheel Grade
RBR-125	Clearance 14 x 2 x 5 usually (R 1/S 8-1/8 X 1)	2A80-P-R
Saw Grinder SS-100	Fluting 12 x (Various) x 3	82A80-Q8-BH
Slot Grinder SG-100	Fluting 12 x (Various) x 5	97A1001-W7-BHQ
Gun Tap Grinder GP-100	Fluting 18 x .250 x 8	2A120-T-R
GP-125	Fluting 1 x (Various) x 3	2A100-T-R
Tap Shank Squaring Machine SQ-150	Clearance 30 x (Various) x 12	12A54-S7-B90
End Mill Grinder EM-110	Fluting 20 x .625 x 12	82A100-R8-BH
EM-120	Fluting 20 x (.375, .500, .625) x 12	82A100-R8-BH
EM-100	Clearance 30 x (Various) x 12	82A54-R8-BH
Diamond Roll Grinder PLG-100	Fluting 18 x (Various) x 8	82A100-R8-BH
Relief Grinder RG-110 RG-110 RG-120	14 X 3 X 10, 2" rim (Plate mounted) 14 x 1/4 x 11/4 four 9/16" plain holes on a 4-3/4" bolt circle	12A60-J9-B90
Crankshaft Point Grinder CSG-12	12 x 3/8 x 3	12A80-J9-VFM

Applications (Fluting)

The wheels covered by this application guide are used primarily for fluting, slotting, clearing, gashing, and gun pointing on cutting tools such as taps, reamers, drills, end mills, router bits, etc. Whereas in thread grinding, stock removal amounts are relatively small, in flute grinding (and related areas) the plunge operation removes larger amounts of material in a single pass. The most common machines encountered are HERTLEIN and NORMAC machines.

You must pay particular attention to wheel speeds as some of the newer NORMAC machines operate at 16,000 SFPM (6" & 8" diameter wheels) w hile the HERTLEIN machines generally operate around 12,000 SFPM. The high speeds tend to increase the wheel efficiency but may also require a specification change if burn starts to develop. The most commonly encountered wheel diameters are: 3", 6", 8", 10", 12", 15", 16", 18" and 20". Thicknesses will vary from .070 up to .625. The most commonly used abrasives for flute grinding are: 2A, 9A, 12A, 97A and the most commonly used bond systems are BHJ and BHQ, see 15-4.

Because tap flutes are usually short and fairly shallow, harder grades and rougher grains can be used. Production rates are high and dressing cycles can vary widely. When grinding spiral drill flutes the problems encountered are different. Here you have a long uninterrupted deep plunge cut. Wheel shape must be held while burning is kept to a minimum to avoid metallurgical damage. Special tough, yet friable abrasives are required to do this job matched up with the proper bond type. If required, coolant slots (side grooves) are available to aid in reducing a burning condition.

The following information is to be used as a starting guide and may not necessarily be the only specifications for the job.

When ordering be sure to specify the speed at which the machine is operating.

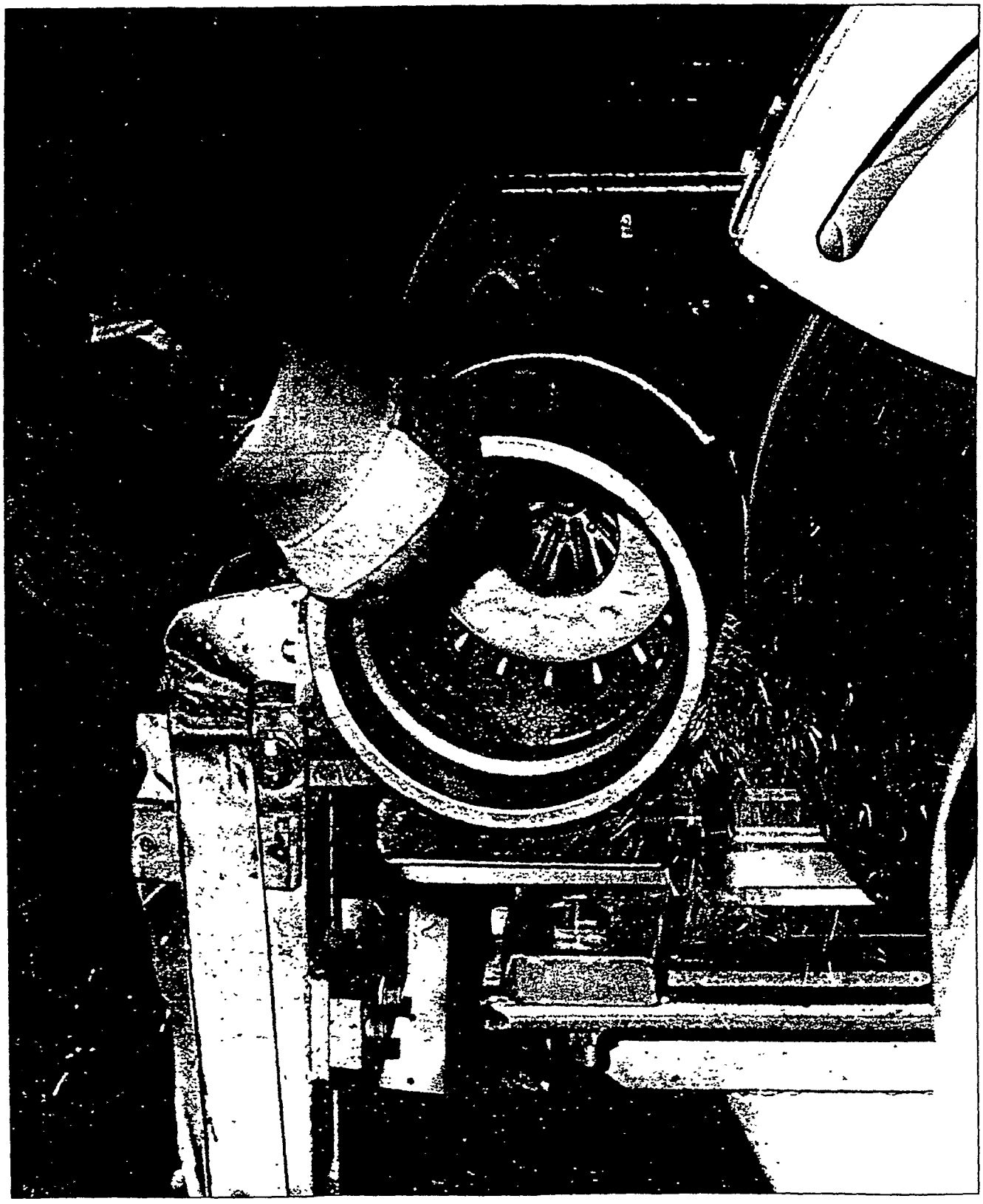
Fluting

Wheel Dia. (mm)	Thickness	End Use	General Specifications	HERTLINE	DA Recommendation
>100<200	Variable	Straight Fluting Taps 8mm	AK120-V11-B5	AK100-V11-BL7331	DA100-V11-B5
	Variable	>8mm<13mm	AK120-V11-B5	AK100-V11-BL7331	DA100-V11-B5
	Variable	>13mm	AK100-V11-B5	AK100-V11-B5	DA100-V11-B5
	Variable	Straight Fluting Reamers	AK120-V11-B5	AK100-V11-BL7331	DA100-V11-B5
>200MM	Variable	Straight Fluting Extra Long Reamers & Taps	AK100-V11-B5	AK100-V11-BL7331	DA100-V11-B5
>300<500	Variable	Fluting Centre Drills	AK100-S8-BH	AK100-X11-BZ	DA100-X11-BL3206
	Variable	Fluting Short End Mills	AK100-S8-BH	AK100-X11-BZ	DA100-X11-BL3206
	Variable	Fluting Router Bits (Small)	AK100-V11-B5	AK100-V11-BL7331	DA100-V11-B5
	Variable	Fluting Router Bits (Large)	AK100-Q8-BH	AK100-R8-BH	DA100-S8-BH
<300	<2	Spiral Fluting of Drills & Taps	AK150-R8-BH	AK180-S8-BH	DA150-S8-BH
	>2<3.5		AK120-Q8-BH	AK120-R8-BH	DA120-S8-BH
	>3.5<4.75		AK120-Q8-BH	AK120-R8-SH	DA120-S8-BH
	>4.75		AK120-Q8-BH	AK120-Q8-BH	DA120-R8-BH
>300	>2<4.75	Spiral Fluting of Soft End Mills	AK120-P8-BF	AK120-S8-BF	DA120-S8-BH
	>4.75		AK120-P8-BF	AK120-S8-BH	DA120-S8-BH
	>2<4.75	Spiral Fluting of Tough Steel End Mills	AK100-R8-BH	AK100-X11-BZ	DA100-X11-BL3206
	>4.75		AK100-S8-BH	AK100-X11-BZ	DA100-X11-BL3206
>300<500	<4.75	Spiral Fluting of Drills & Taps	AK120-P8-BF	AK120-Q6-BH	DA120-Q8-BH
	>4.75		AK120-Q8-BH	AK120-R8-BH	DA120-R8-BH
	<4.75	Spiral Fluting of End Mills	AK120-P8-BF	AK120-R8-BH	DA120-S8-BH
	>4.75		AK100-S8-BH	AK100-X11-BZ	DA100-X11-BL3206
	>4.75	End Mills - Soft Steels	AK60-S8-BH	AK54-S8-BH	DA54-S8-BH
>300<500	<6mm	Gun Pointing Spiral Taps	AK150-Q8-BH	AK120-S8-BH	DA120-S8-BH
	>6mm		AK100-Q8-BH	AK80-S8-BH	DA120-S8-BH
	Variable	Gun Pointing Straight Taps	AK120-V11-B5	AK100-V11-BL7331	DA100-V11-BL7331
	Variable	Slotting Long Drills 25mm	AK100-S8-BH	AK100-S8-BH	DA100-T8-B5
	Variable	Slotting Small Taps - Reamers	AK120-V11-B5	AK100-V11-BL7331	DA100-V11-B5
	<25mm	Drill Step	AK80-P8-BF	AK100-Q8-BF	DA100-R8-BH
	<16mm	Gashing End Mills	AK100-S8-BH	AK100-X11-BZ	DA100-X11-BL3206

Trouble Shooting

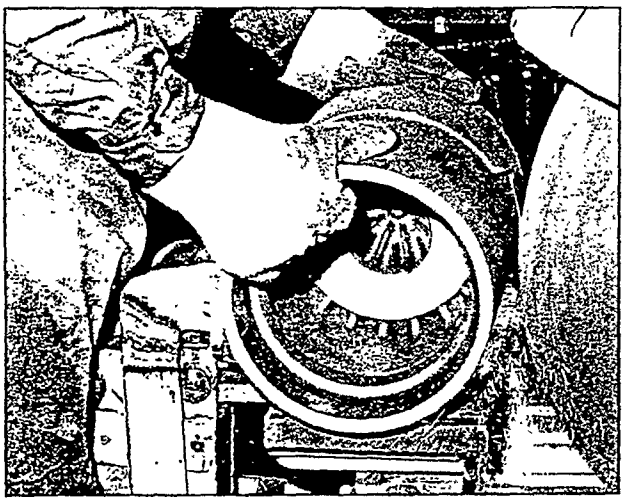
Problem	Possible Cause	Possible Correction
A. Burning or discoloration of work	Not enough coolant	Redirect coolant at cutting point
	Too heavy on infeed	Reduce amount of stock removed per pass
	Too slow work speed	Increase work speed and reduce infeed proportionally
	Direction of cutting cycle	Change cycle to finish or "upcut"
B. Maintaining proper root width	Wheel too coarse	Change to finer grit size
	Wheel too slow	Increase wheel speed on narrow roots
	Proper coolant flow on work piece	Ensure coolant is directed at the cutting point
	Poor diamond dressing	Dress from point of wheel toward edges
C. Poor Thread form (other than root)	Dressing diamond worn or loose	Replace or tighten nib
	Dressing cut too heavy	Take lighter cuts
D. Lead error	Wheel deflection	Change to thicker wheel or use larger flanges
E. Poor finish and chatter	Diamond scratch lines evenly placed	Change dressing procedure
	Surface roughness	Use lighter cut or slower work speed on finish pass
	Scratches	Clean oil
	Out of balance wheel	Retrue and rebalance
	Work speed too high	Use slower work speed

16 Snagging Wheels



Snagging Wheels

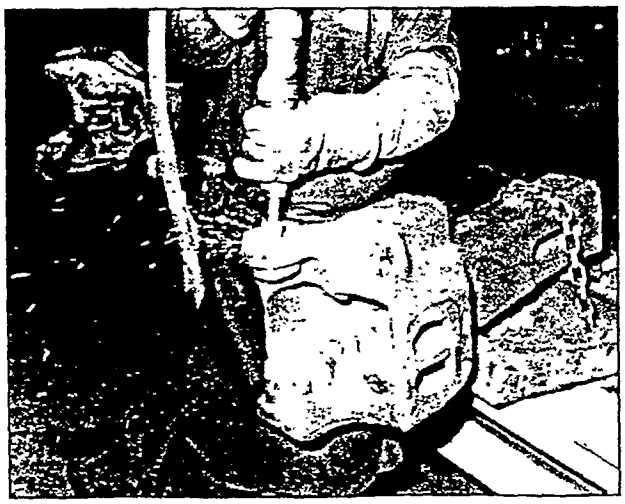
Large diameter snagging wheels are ideal for applications which require the fast removal of large amounts of metal. They are engineered for most swing frame or floor stand grinders.



Snagging wheels are available in a full range of abrasive grains, including Zirconia, and in a complete range of non-reinforced and reinforced wheels in diameters up to 42 inches.

Resin Bonded Portable Wheels

Straight wheels, depressed center wheels, and cones and plugs are available as a complete line for hand-held portable grinding applications. These wheels are suited for a variety of metal removal jobs, such as removing excess weld beads, cleaning prior to painting, smoothing rough surfaces, and grinding of parting lines, fines and risers. Highly efficient super speed wheels also are available, which are capable of running up to 17,000 SFPM.



Resin Bonded Cups

Straight (T-6) and flaring (T-11), (T-11A) cups are utilized in horizontal grinding applications for rough, heavy stock removal. Cups also are available with or without steel backs.

Resin Wheel Recommendation

High Speed Type 11A Cups*

Wheel Size	Max. SFPM	Cast, Gray Ductile Iron	Malleable (Annealed)	Steel	Stainless Steel
4/3 x 2 x 5/8-18	12,500	R5A167-N-12 27A167-N-12	27A167-N-12 R5A167-N-12	27A467-N-12	27A467-N-12 R5A167-N-12
5/3-3/4 X 2 X 3/4-16	11,800	R5A167-N-11 27A167-N-12	27A467-N-12 R5A167-N-11	27A487-N-12	27A467-N-12 R5A167-N-11
6/4-3/4 x 2 x 7/8-14	12,500	R5A167-N-12 27A167-N-12	27A167-N-12 R5A167-N-12	27A467-N-12	27A167-N-1 R5A167-N-12

*11A - The "A" designates steel back.

Snagging Wheel

Application	9500 SFPM Light Pressure	9500 SFPM Heavy Pressure	12500 SFPM Light Pressure	12500 SFPM Heavy Pressure
Aluminum Castings	R5A16-O4-BCW	R5A16-P4-BCW	R5A16-O4-BCW	R5A16-P4-BCW
Brass, Bronze	R5A16-P4-BF	R5A16-Q4-BF	R5A16-Q4-BF	R5A16-R4-BH
Cast Iron	W5C14-Q4-BF	W5C14-R4-BH	W5C14-Q4-BF	W5C14-R4-BH
Chilled Iron	R5A16-PR-BF	R5A16-P4-BF	R5A16-P4-BF	R5A16-Q4-BF
Ductile Iron	W5A14-P4-BF	W5A14-Q4-BF	W5A14-P4-BF	W1A14-R4-BH
Malleable Iron				
Annealed	W5A14-Q4-BF	W5A14-R4-BH	W5A14-R4-BH	W5A14-R4-B254
Unannealed	W5A14-P4-BF	W5A14-Q4-BF	W5A14-Q4-BH	W5A14-R4-BH
Steel Castings	W5A14-Q4-BH	W5A14-Q4-B254	W5A14-R4-BH	W5A14-R4-B254
Stainless Steel	W5A16-P4-BF	W5A16-Q4-BF	W5A16-P4-BF	W5A16-Q4-BF
Titanium	R5A16-P4-BF	R5A16-Q4-BF	R5A16-P4-BF	R5A16-Q4-BF

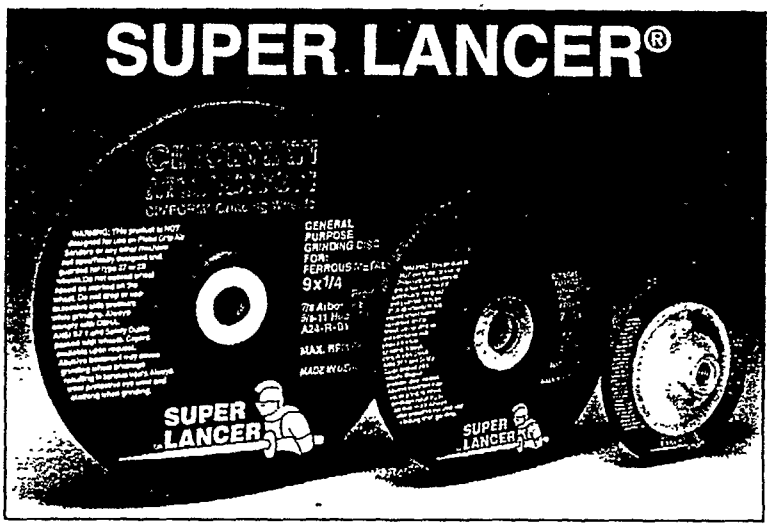
These are starting recommendations for snagging wheels. The reinforcement codes need to be added. Based on competitive specification, these may be altered.

Portable Snagging Wheel

Application	TYPE 1 Straight Wheel	TYPE 6, 11 Cup	T16, 17, 18, 19 CONES & PLUGS
Aluminum Castings	A24-O5-BC2W	A24-O5-BCW	A24-O5-BCW
Brass, Bronze Castings	A24-N5-BCW	A24-O5-BCW	A24-O5-BCW
Billets (Cleaning):			
High Carbon, Low Alloy Steels	AZ16-R-BX or W5A16-R4-BH	AZ16-R-BZ or W5A16-R4-BH	AZ24-R-BX or A24-R4-BH
Stainless Steels	AZ16-R-BX or W5A16-R4-BH	AZ16-R-BX or W5A16-R4-BH	AZ24-R-BX or A24-R5-BH
High Alloy & Tool steels	AZ16-R-BX or W5A16-R4-BH	AZ16-R-BX or W5A16-R4-BH	AZ24-R-BX or A24-R5-BH
General Purpose:			
Ferrous	A16-Q4-BH	A16-P5-BF	A24-R5-BH
Non-ferrous	R5A16-P4-BF	R5A16-O5-BC	C20-O5-BC
Non-Metallic	C24-O5-BC	C24-O5-BC	C24-Q5-BF
Gray Iron Castings	AZ16-Q-BX or AZ14-Q-BX	AZ16-Q-BX or W5A14-Q4-BF	AZC24-R-BX or R5A24-R5-BH
Buried In Sand	AZC14-Q-BX	AZC14-Q-BX or W5C14-Q4-BF	AZC24-R-BX or 15C24-R-BX
Malleable Iron & Steel			
Castings (annealed)	AZ16-R-BX or W5A16-Q4-BH	AZ16-R-BX or W5A16-R4-BH	AZ24-R-BX or A24-R4-BH
Malleable Iron Castings (unannealed)	AZC14-Q-BX or 15C14-Q4-BF	AZC14-Q-BX or 15C14-Q4-BF	AZC24-R-BX or C24-S4-B254
Titanium	C20-Q5-BF	C20-Q5-BF	C20-05-BF
Track Welds	AZ24-R-BX or W5A24-R4-BH	AZ16-R-BX or W5A16-R4-BH	AZ24-R-BX or A24-R4-BH
Welds:			
Carbon Steel	AZ16-Q-BX or W5A16-R5-B254	AZ16-Q-BX or W5A16-R4-B254	AZ24-R-BX or A24-R4-B254
Stainless Steel	AZ16-R-BX or W5A16-S5-B254	AZ16-R-BX or W5A16-R4-B254	AZ24-R-BX or A24-S4-B254

All Resin wheels run 9500 SFPM except reinforced Type 1 - 12500 SFPM maximum.

17 Type 27 & 28 Super Speed



APEX 2000 and SUPER LANCER Depressed Center Grinding Wheels for Your Portable Application

APEX 2000 and SUPER LANCER Grinding Wheels were specifically developed for improved performance and productivity in your portable applications. APEX 2000 with zirconia alumina abrasive, and SUPER LANCER aluminum oxide wheels will consistently outperform your standard depressed center grinding wheels.

Cincinnati Milacron understands the unique requirements of your portable operations. Years of research and bond development have resulted in real breakthroughs in our grinding wheels.

APEX 2000 and SUPER LANCER Grinding Wheels are excellent for difficult applications and hard to grind materials, such as high nickel and high carbon steel alloys, and other exotic alloys. They are also the wheels of choice for weld grinding applications.

Our grinding wheels are designed to give you the winning edge. They last four times longer than standard aluminum oxide wheels, which means less downtime for wheel changes. They stay sharper longer and require less pressure to grind, thereby increasing your operators' productivity.

MIL 000255

Resin Wheel Recommendation

PORTABLE SUPER SPEED WHEEL

Type 1	Max SFPM	Material	Recommended Spec.	Material	Recommended Spec.
6 x 1 x 1	17,000	Steel Castings	A24-P-17	Stainless	
8 x 1 x 1	17,000	Hardened Steel	A24-P-17	300 Series	A24-Q-17
		Low Carbon	A24-R-17		R5A25-Q-17
		Manganese	A24-P-17	400 Series	A24-R-17
		Monel & Hi-Nickel	A24-P-17	Welds	A24-P-17
		Alloys	R4A24-Q-17	Malleable	
		Cast & Gray Iron	R5A24-P-17	(Annealed)	A24-Q-17
		Ductile & Nodular	R5A24-Q-17	Meehanite	R5A24-Q-17
			A24-Q-17	Ni-Hard	C24-Q-17

DEPRESSED CENTER GRADES

	SUPER LANCER				APEX 2000
Size	Type	Metals	Alum	Masonry	Metals
3x1/8x3/8	27	A24-R&T	A24-P	C24-P	AX24-T&V
3x3/16x3/8	27	A24-R&T	A24-P	C24-P	AZ24-T&V
3x1/4x3/8	27	A24-R&T	A24-P	C24-P	AZ24-T&V
4x1/8x3/8	27	A24-R&T	A24-P	C24-P	AZ24-T&V
4X1/8X5/8	27	A24-R&T	A24-P	C24-P	AZ24-T&V
4X.125X3/8	27	A24-R&T	A24-P	C24-P	AZ24-T&V
4X3/16X3/8	27	A24-R&T	A24-P	C24-P	AZ24-T&V
4X3/16X5/8	27	A24-R&T	A24-P	C24-P	AZ24-T&V
4X1/4X3	27	A24-R&T	A24-P	C24-P	AZ24-T&V
4X1/4X5/8	27	A24-R&T	A24-P	C24-P	AZ24-T&V
4-1/2X1/8X7/8	27	A24-R&T	A24-P	C24-P	AZ24-T&V
4-1/2X1/8X5/8-11	27A	A24-R&T	A24-P	C24-P	AZ24-T&V
4-1/2X.125X7/8	27	A24-R&T	A24-P	C24-P	AZ24-T&V
4-1/2X3/16X7/8	27	A24-R&T	A24-P	C24-P	AZ24-T&V
4-1/2X3/16X5/8-11	27A	A24-R&T	A24-P	C24-P	AZ24-T&V
4-1/2X1/4X7/8	27	A24-R&T	A24-P	C24-P	AZ24-T&V

	SUPER LANCER				APEX 2000
Size	Type	Metals	Alum	Masonry	Metals
4-1/2x1/4x5/8-11	27A	A24-R&T	A24-P	C24-P	AZ24-T&V
5x1/8x7/8	27	A24-R&T	A24-P	C24-P	AZ24-T&V
5X1/4X7/8	27	A24-R&T	A24-P	C24-P	AZ24-T&V
6X1/4X7/8	27	A24-R&T	A24-P	C24-P	AZ24-T&V
7X1/8X7/8	27	A24-R&T	A24-P	C24-P	AZ24-T&V
7X1/8X5/8-11	27A	A24-R&T	A24-P	C24-P	AZ24-T&V
7X1/4X7/8	27	A24-R&T	A24-P	C24-P	AZ24-T&V
7X1/4X5/8-11	27A	A24-R&T	A24-P	C24-P	AZ24-T&V
9X1/8X7/8	27	A24-R&T	A24-P	C24-P	AZ24-T&V
9X1/8X5/8-11	27A	A24-R&T	A24-P	C24-P	AZ24-T&V
9X1/4X7/8	27	A24-R&T	A24-P	C24-P	AZ24-T&V
9X1/4X5/8-11	27A	A24-R&T	A24-P	C24-P	AZ24-T&V
7X1/4X7/8	28	A24-R&T	A24-P	C24-P	AZ24-T&V
7X1/4X5/8-11	28A	A24-R&T	A24-P	C24-P	AZ24-T&V
9X1/4X7/8	28	A24-R&T	A24-P	C24-P	AZ24-T&V
9X1/4X5/8-11	28A	A24-R&T	A24-P	C24-P	AZ24-T&V

18 Thread Grinding

Starting Grade Recommendations

Type of Thread	Threads per inch	Precut Thread	From Solid
Fine pitch screws	32 to 40	97A2201-M4-VRW	12A220-S6-B90
Amer. Natl. Form Thread			
Screws, Studs	8 to 12	97A601-L4-VRW	97A1001-R9-B90
And Bolts	14 to 20		97A1201-R9-B90
(Ameican National	24 to 28	97A801-M4-VRW	97A1501-S7-B90
Form Threads)	32 to 36		97A1801-S7-B90
	40 to 44	97A1501-M4-VRW	12A220-S7-B90
Taps (High Speed Steel)	4 to 12	12A80-J6-VRW	97A1001-Q9-B90
N.C. and N.F. Threads	14 to 20	12A120-L4-VRW	97A1201-R9-B90
	24 to 36	12A220-L4-VRW	97A1801-S7-B90
Pipe Thread Taps	8 to 18	97A1001-L4-VRW	97A1001-S7-B90
(American Standard	20 to 26		97A1501-T7-B90
Pipe Threads	27	97A1501-M4-VRW	97A1801-T7-B90

Specification & Selection
B-H Resin Bonded Wheels

Chart II External Thread Grinding	Type Thread	Threads Per Inch	Specifications Commercial Quality
	Acme	8-18 (From Solid)	2A100-S7-BH
			12A100-S7-BH
Taps		20-26 (From Solid)	2A150-T7-BH
M-2 High			12A150-T7-BH
Speed Steel		27-32 (From Solid)	12A180-T7-BH
63-65 Rockwell Hardness			12A180-V7-B5
	American	4-12 (From Solid)	2A100-S7-BH
	National Fine		12A100-S7-BH
	Threads	14-20 (From Solid)	2A120-S7-BH
			12A120-S7-BH
		24-32 (From Solid)	12A180-T7-B5
			12A180-V7-B5
			2A220-WY-BH
	American	8-18 (From Solid)	2A100-S7-BH
	Standard Pipe		12A100-S7-BH
	Threads	20-26 (From Solid)	2A150-T7-BH
			12A150-T7-BH
		27-32 (From Solid)	12A150-T7-BH
			12A150-V7-B5
			12A180-V7-B5

Notes to Selection Guide:

1. 2A is the standard abrasive.
   12A is our premium grain to be used on special metals and alloys.
2. All trial specifications should be in "7" structure to start. The 5" and 9" structures are used only to fine tune a specification.
3. Pay particular attention to wheel speeds and work speeds. They are important in determining the proper hardness.
4. "W" and "X" grades available if required. Try softer grades first.

Surface Feet Per Minute

Wheel Diameter SFPM	Revolutions Per Minute 9,000	10,000	12,000
12	2864		
14	2455		
16	2149		
16		2387	2865
18		2122	2546
20		1910	2292
24		1591	1910

Standard Wheel Sizes: External Thread Grinders

Machine	Wheel Size
DAIZEN #1	16 X 1/4 X 7
DAIZEN #2	12 X 1/4 X 7
EXCELLO	18 X 3/8 X 9
JONES and LAMSON	20 x 3/8 x 10
LANDIS	20 x 3/8 x 10

Thread Grinding Wheels Resin Bond Operating Speed 12,000 SFPM All Grain Types

Bond Types - B90 & BH

Grain Size	54-60-70	80 and finer
Grade	"P" and harder	"N" and harder
	Maximum Operating Speed RPM	
O.D.		
16	2865	
18	2546	
20	2292	
24	1910	

Wheels must be for use on conventional thread grinding machines and orders must be labeled "Thread Grinding".

American Standard Thread

Threads/in.	Root Width	Coarsest Grit Size Resin Bond	Coarsest Grit Size Vitrified
40	.0031	220	220
36	.0035	180	220
32	.0039	180	180
28	.0044	150	180
24	.0052	150	150
20	.0062	120	120
18	.0069	100	120
16	.0078	100	120
14	.0089	100	100
13	.0096	90	100
12	.0104	90	90
11	.0113	90	90
10	.0125	80	90
9	.0139	80	80
8	.0156	80	80
7	.0178	80	80
6	.0208	70	80
5	.0250	70	80
4 1/2	.0278	60	70
4	.0312	60	70

The grit sizes in this chart are subject to the limits of the grain charts in the Engineering Data Book.

Following are some general recommendations of starting grades for average thread grinding operations. The vitrified grades shown can be used for either diamond dressing or crush forming.

Acme or worm threads	4 to 6	12A80-J6-VRW	2A80-P8-B90
	8 to 12	12A100-J6-VRW	2A100-R9-B90
	12 to 16	12A120-J6-VRW	97A1201-O9-B90

Diameter/Thread Pitch Comparison

Inch Series			Metric Series			
Size	Dia. (In.)	TPI	Size	Dia. (In.)	Pitch (mm)	TPI (Approx.)
#0	.060	80				
			M1.6	.063	.35	74
#1	.073	64				
			M2	.079	.4	64
#2	.086	56				
			M2.5	.098	.45	56
#3	.099	48				
#4	.112	40				
			M3	.118	.5	51
#5	.125	40				
#6	.138	32				
			M4	.157	.7	36
#8	.164	32				
#10	.190	24				
			M5	.196	.8	32
			M6	.236	1.0	25
1/4	.250	20				
5/16	.212	18				
			M8	.315	1.25	20
3/8	.375	16				
			M10	.393	1.5	17
7/16	.437	14				
			M12	.472	1.75	14.5
1/2	.500	13				
			M14	.551	2	12.5
5/8	.625	11				
			M16	.630	2	12.5
3/4	.750	10				
			M20	.787	2.5	10
7/8	.875	9				
			M24	.945	3	8.5
1"	1.000	8				
			M27	1.063	3	8.5

Vitrified Bond Thread & Flute Grinding Wheels Type 1 Only

Standard maximum operating speed for thread grinding is 12,000 SFPM for high strength vitrified bonds. Wheels used for thread grinding within the range described below do not require an "E" or an over-speed label.

Maximum Operating Speeds

	VFM 2A, 4A, 9A, 97A, 12A VRW Grain in Structures 4 and 6		
ID	7	9, 10 & 12	
	54-220: H and Harder	54-70: H and Harder 80-220: H and I	80-220: J and Harder
SFPM	9,000	10,000	12,000
OD	RPM	RPM	RPM
12	2864		
14	2455		
16	2149	2387	2865
18		2122	2546
20		1910	2292
24		1591	1910

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MIL 000259

Thread Grinding

Thread grinding can be generally classified into two categories, namely single-rib and multi-rib methods of thread grinding. The multi-rib method can be further described as multi-rib plunge cut, multi-rib traverse and centerless methods. The centerless method can be further divided into the traverse method for headless parts and the plunge cut method for cap screws, bolts, etc.

The majority of thread grinding is done by the single-rib method or single-edged wheel. The periphery of the wheel is trued to the exact form of the thread to be ground and the wheel swiveled to match the helix angle of the thread.

Wheels for this type of thread grinding are usually dressed with single-point diamond dressing tools designed to fit the special dressing attachments of the machines. The grinding wheels may be vitrified or resin bond, depending on the accuracy of the thread required or the operation involved. Vitrified wheels are used when grinding pre-cut threads that have been distorted by hardening or to correct lead error in the thread and when grinding thread gages where very accurate threads are required. Resin bond wheels are generally used when grinding from the solid rod.

Thread grinders are equipped with a variable speed spindle for the grinding wheel, making it possible to increase spindle speed to maintain a constant SFPM as the wheel wears down. Wheel speed on thread grinding varies from 6500 SFPM to 12,000 SFPM, and while most grades of thread grinding wheels are safe at these speeds, there are exceptions when material is hardened or the design of the part requires a coarse and softer wheel. The speed marked on the wheel by the wheel manufacturer must not be exceeded. The work speed is usually determined by trial; one work speed for all classes of work would not be practical. A work speed of 2½ SFPM would be a good starting point on medium pitch threads ground from the solid.

Grinding oil has proven to be the best coolant to use for both vitrified and resin bonded wheels. It helps the wheel to hold form, produces a better finish, and keeps the wheel clean and free-cutting. The application of coolant is as important as volume. Keep the nozzles adjusted to direct coolant on the part and wheel at point of contact.

When selecting a grade of wheel to grind threads, the bond is considered first, the bond type used depending on type of operation. If grinding pre-cut threads or thread gages, use vitrified bond. Resin bond is used on high production jobs where threads are ground from solid in as few passes as possible and as many pieces as can be ground within tolerance between dresses for a greater number of pieces per dress and give a brighter finish than vitrified bond.

The grain type is not as critical as in other types of precision grinding. The majority of jobs, both soft and hardened, can be ground satisfactorily with regular and semi-friable grain. Internal thread grinding, due to the longer arc of contact, needs the cooler cut of the full friable grain.

The grit size is controlled by the root width of the thread to be ground. The root width varies inversely with the number of threads per inch; the greater the number of threads per inch the narrower the root width. It is impractical to grind a thread with a root width smaller than the cross section of the grain. The dressing diamonds would have to machine the grain on the edge of the wheel to a smaller size. The grain usually breaks out from the pressure of the diamond, making a ragged edge on the periphery of wheel that may develop chatter in the root of the thread.

See the chart on page 16-2 for coarsest grit size recommended to grind American Standard Thread Form.

Multi-Rib Thread Grinding

The term multi-rib describes the wheel face, meaning the wheel has 2 or more ribs dressed on the periphery corresponding to the number of threads per inch the wheel will grind. Each rib is dressed to the form of the thread by either crush dressing or diamond dressing. The grinding wheel usually is as wide as the thread is long or wider, and is plunged into the full thread depth in the first half-revolution of the part. The full length and depth of the thread is completed in one and one-half revolutions of the workpiece.

The Skip Rib method of multi-rib thread grinding uses a wheel that is as wide or wider than the length of the thread, having the ribs spaced to grind every other thread during the first revolution of the work, and completing the thread with the second revolution of work. This method requires 2½ revolutions of the work to complete the thread and works especially well where resinoid wheels must be used on fine pitch threads. This wheel form lends itself readily to very accurate diamond dressing and permits better distribution of coolant, usually giving more parts per dress than the multi-rib or single-rib method.

Multi-Rib Thread Grinding (cont.)

The centerless method of thread grinding can be used on work that can be fed through the grinder (similar to thrufeed) such as headless set screws, headless bolts, tubing or pipe, etc. The grinding wheel generally is from 2" to 5" wide and the thread form is crush-trued on the wheel; the regulating wheel then feeds the work across the grinding wheel as does a thrufeed grind. The machines have to be especially equipped for crush-truing and this type of work.

It is impractical to crush-form a thread when the root width is less than .005" or when the thread is finer than 20 threads per inch. Crush-dressing is not recommended for better than a class 3 fit, however, it is possible to obtain a class 4 fit by the centerless method on a production basis.

Grit Size and Type

- Usually start with standard A abrasive.
- To reduce burning, go H5A to 10A.
- Grit size depends on size of flute and thread.
  Coarse Thread — 8-20 threads/inch — 80 grit
  Medium Thread — 20-26 threads/inch — 120 grit
  Fine Thread — 27-32 threads/inch — 180 grit

Normal Grades — Cold Press - R-V; Hot Press - X11

Rule of Thumb

When grinding threads from the solid, resinoid wheels work best, i.e. H5A80-T9-B5. When grinding precut threads, use vitrified grinding wheel, i.e. 9A80-P4-VFME.

Carlisle FDT Wheels — Cold Press

Grade	Q-S	S-T	T-U-V
Bond	BH	B254	B5

Carlisle FDT Wheels - Hot Press

Softest			Hardest
BL6823	BL3206	*BZ243	BL1830

**Normal trial would be BZ243*

Trouble Shooting

Burning of Work:

Make sure there is a sufficient volume of coolant directed where it will flood the contact area between the wheel and the work. Burning can be caused by too heavy feed or too fast work speed — take lighter cuts at reduced work speeds.

On hardened high-speed steel, a change to a smaller grit size will often reduce burning.

Direction of work rotation is often critical in thread grinding. Some work will burn when rotated in climb-cut direction and not burn when rotated in the opposite direction to wheel rotation, or the up-cut direction. Finish cuts should always be made with work rotating in the up-cut direction.

Thread Form:

Poor thread form is usually caused by dressing or truing the wheel; check diamonds for cracks or loose diamonds. Also, if diamond is dull, the side pressure developed on the wheel by the diamond may cause the wheel to deflect enough to affect the thread form.

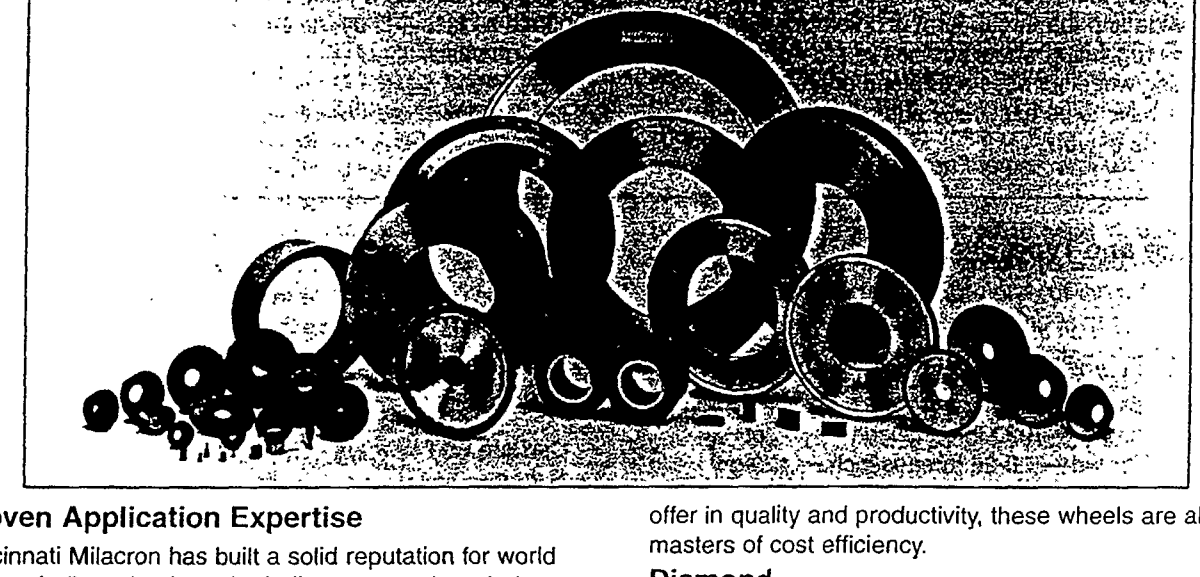
Lead Error:

Lead error is a common problem when using a resin bond wheel to grind a pre-cut thread. It is advisable to use vitrified bonded wheels on pre-cut threads. The vitrified wheel is not as flexible as the resin wheel and will correct the lead error instead of deflecting and following the pre-cut thread. If conditions dictate the use of resin bond, then thicker wheels or larger diameter flanges will help resist deflection of the wheel.

Chatter:

Chatter in thread grinding can be the result of the same conditions which cause other grinding problems: wheel out of balance, glazed wheel from dull diamond, too high work speed, etc. Truing a sharp edge on a coarse grit wheel (such as is generally used on coarse pitch threads) causes a ragged edge on the periphery of the wheel, which will sometimes cause chatter in the root of the thread. If a small flat is dressed on the periphery of the wheel, it will stop chatter from this source.

19 Diamond and CBN Superabrasives



Proven Application Expertise

Cincinnati Milacron has built a solid reputation for world class grinding wheels and grinding process knowledge by developing advanced technology products like Superabrasive Grinding Wheels. As a result of its long-standing reputation as a leading manufacturer of machine tools, conventional and superabrasives, and high performance metalworking fluids, Milacron has the unique distinction within the grinding industry of a total systems approach.

Nobody knows more about advanced technology grinding than Cincinnati Milacron . . . from automotive cam shafts to aircraft engine parts . . . from carbide tipped tooling to the most advanced alloys. Wherever there is a need for state of the art grinding wheels and process knowledge, a Cincinnati Milacron Representative will be there to help determine precisely the right wheel and metalworking fluid.

Superabrasives: Your Competitive Edge

The grinding wheels of tomorrow are here today — Cincinnati Milacron Products Division's Superabrasives. The term superabrasive refers to the extraordinary hardness of diamond and CBN abrasives.

Diamond is the hardest material known to man, and is three times harder than its conventional abrasive counterpart, silicon carbide. CBN (cubic boron nitride) is second in hardness only to diamond, and is twice as hard as its conventional counterpart, aluminum oxide.

Super hard with exceptional wearability, Diamond and CBN wheels reduce grinding time and help eliminate common problems like burn, part-to-part variations, and excessive downtime due to wheel dressing. Best of all, with the continuous improvement the Superabrasives offer in quality and productivity, these wheels are also masters of cost efficiency.

Diamond

Cincinnati Milacron's Bonded Diamond wheels are custom engineered for the grinding of extremely hard, nonferrous materials such as carbide, glass, ceramics, and titanium. They perform exceptionally well when used to grind and sharpen carbide tooling, grind dies, bevel glass, engineered ceramics and grind carbide tipped saws. Only the finest synthetic virgin diamonds are used, and the diamonds for each type of wheel are engineered especially for specific applications.

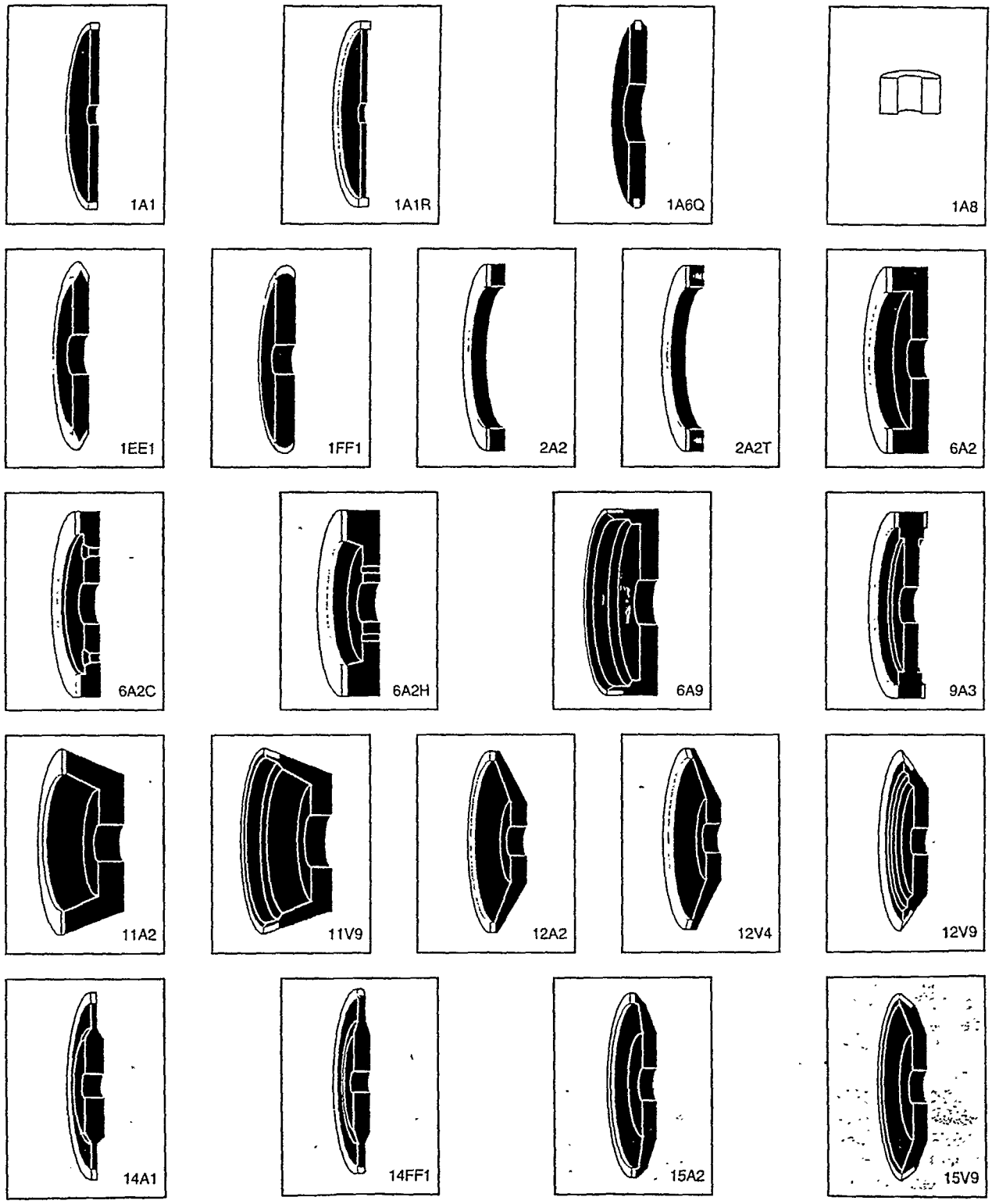
CBN — Cubic Boron Nitride

CBN, cubic boron nitride, is second only to diamond in hardness. Cincinnati Milacron carefully engineers the bonds in these wheels for ferrous grinding such as the automotive compressor bearing and aerospace industries, where super hard materials like hardened tool and die steel, alloys and superalloys, stainless steel, and cast iron are being used. They are ideal for grinding and resharpening tooling, surface grinding, superfinishing, and groove grinding.

Cincinnati Milacron's Marathon™ Vitrified Bonded CBN wheels are designed for high production and high precision grinding of such ferrous materials as bearing steels (52100, M50, and 8620), alloys, superalloys — especially aircraft materials, cast iron, and powdered metal. They are ideal for use in production grinding of bearing bores (D grinding), cylindrical grinding, and in applications involving difficult to grind aircraft and automotive parts and rotary compressors. Applications include internal, cylindrical camshaft and crankshaft surface and creep-feed grinding.

Superabrasive Grinding Wheels Are Available In a Variety of Shapes

(All types are not listed. These are examples of the most common shapes used in the industry.)



MIL 000263

MARATHON™ Grinding Wheels Availability and Markings Vitrified Cubic Boron Nitride (CBN) for High Production Grinding

Selecting The Wheel Specifications

The MARATHON™ wheel is a unique product for high-production grinding of hardened ferrous metals.

Applications

- Bore Grinding
- Bearing Notch Grinding
- Bearings
- Room Air Conditioner Components
- Fuel Injection Components
- Automotive Parts (i.e. camshafts, crankshafts)

Machine Capabilities Needed

- Reproducible Diamond Dress Compensation
  0.0001" desirable
- Skip Dress Capability
  Automatic Preferred
- Grinding Fluid
  Necessary and Critical
- Rotary Diamond Trueing Device

Materials

Ferrous materials over 50 Rc

- Hardened Tool & Die Steels
- Hardened Steels and Cast Irons
- Stellite and Super Alloys

Grit Size

The surface finish and metal removal rate requirements determine grit size.

- 15 Microinch RMS and Less
  Use 180 Grit and Finer
- Over 15 microinch RMS
  Use 150 Grit of Coarser

Wheel Shapes

- Types 1A8 (Solid) and 1A1 (Rimmed).
- Mounted Wheels — 1A8-W, 1A1-W.
  Some wheel sizes are available as mounted wheels with straight or tapered shanks, or flanged threaded mandrels.

Wheel Sizes

- Minimum Diameter — 1/4"
- Maximum Diameter — 24"
- Minimum Thickness — 1/4"
- Maximum Thickness — 7/8" (one piece)

ID sizes vary with equipment availability.

When converting from conventional wheels that grind on the periphery, do not reduce the CBN wheel OD. This reduces SFPM and with it, grinding efficiency. Reducing the size of wheel can be done if the SFPM can be maintained with a higher RPM.

Wheel Speeds

6500-20,000 SFPM. Rigidity of set-up is important, especially at higher speeds. Speeds as low as 2500 SFPM have been successful for very small diameter MARATHON™ grinding wheels. Vitrified CBN wheels show increased grinding efficiency at higher wheel speeds.

Mounting, Trueing & Dressing

For an in-depth explanation, see the section entitled Mounting, Trueing and Dressing.

For assistance on a specific application, contact your local Cincinnati Milacron Grinding System Engineer (GSE).

Grinding Fluid

Maximum performance can be achieved by using a fluid providing high lubricity. Cincinnati Milacron offers a wide range of CIMCOOL® Metalworking Fluids to meet your individual grinding requirements.

2BN 150-R100-VHA 1/16

Grit Type	Grit Sizes*	Grades	Concentrations**	Bonds	Depth of CBN
2BN	60 Thru 320	P-R-T-U	100-125-150	VHA (Vitrified)	***
2BN	60 Thru 320	P-R	100-125-150	VHC (Vitrified)	

* 60, 80, 100, 120, 150, 180, 220, 240, 280, 320
** Other Concentrations Available See Your Local Grinding System Engineer (GSE) For Assistance
*** When Wheels With a Rim are Used

CBN Type & Application

CBN Type	Grinding Condition
2BN (Uncoated)	Wet Only

Bond Types

Bond	Use
VHA	Wet Only Replaces Aluminum Oxide Wheels
VHC	Wet Only Replaces Silicon Carbide Wheels

MARATHON 2 Vitrified Bond Open Structure CBN Wheels

Grit Type	Grit Sizes	Grades	Concentrations	Bonds	Depth of CBN
2BN Uncoated	60 Thru 320	M-N-O-P	80-150	VEA	
2BN Uncoated	60 Thru 240	M-N-O	100-150	VEC	
2BN Uncoated	60 thru 320	M-N-O-P	.164	VEB	***
2BN Uncoated	60 thru 240	M-N-O	100-150	VMA	
2BN Uncoated	60 thru 240	M-N	100-150	VMC	
2BN Uncoated	60 thru 240	M-N-O	164	VMB	

*** When Wheels With Rims Are Used

MIL 000264

Resin Bonded Cubic Boron Nitride (CBN) Wheels Availability and Markings

Selecting The Wheel Specifications

Materials

- Hardened Tool & Die Steels
- Hardened Steels and Cast Irons
- Stellite and Super Alloys

Wheel Grade

Use the hardest grade you can use without causing heat damage to the wheel or work.

Most applications fall within the following grade ranges:

- Q-S-U for B4 Bond
- T-W for B7 Bond
- T-W for BBL Bond

Concentration

Most applications fall within the following ranges:

- 80-100 Concentration for B4 and B4Y Bond
- 66-88 Concentration for B7 Bond
- 66-88 Concentration for BBL Bond

Wheel Sizes

When converting from conventional wheels that grind on the periphery, do not reduce the CBN wheel OD. This reduces SFPM and with it, grinding efficiency only if SFM can be maintained with higher RPM.

Wheel Speeds

- Dry Grinding: 3500-5000 SFPM — at higher speeds, there is danger of workpiece burning.
- Wet Grinding: 4000-9000 SFPM — for best wheel life, 6500-8500 is good. At higher speeds, wheel balance and machine rigidity are a large factor in performance.

Feed Rates

Excessive feed rates cut down on wheel life and should ordinarily be avoided. Contact your local GSE for cycle optimization.

Mounting, Trueing & Dressing

The techniques for mounting, trueing and dressing resin bond CBN wheels are the same as diamond with the following exceptions:

- A diamond impregnated tool (metal bonded particle diamond) about 80-150 mesh can be used to true CBN wheels.
- Use vitrified bonded aluminum oxide trueing wheels to true CBN wheels.

For an in-depth explanation, see the section entitled Mounting, Trueing and Dressing.

For assistance on a specific application, contact your local Cincinnati Milacron Grinding System Engineer (GSE).

Grinding Fluid

Recommended for grinding, trueing and dressing whenever possible. However, economical results can be achieved on wet or dry applications. We recommend Cincinnati Milacron's CIMCOOL® Metalworking Fluids for best results.

1BN 150-U100-B4 1/8

Grit Type	Grit Sizes*	Grades	Concentrations**	Bonds	Depth of CBN
1BN	46 thru 320	Soft-M-O-Q-S-U-Hard	Low-80-100-High	B4, B4Y (Resin)	
1BN	46 thru 320	Q — Light Duty T — General Purpose W — Heavy Duty	Fixed Q=44 T=66 W=88	B7 (Resin)	***
BN ****	100, 150, 220	Q — Light Duty T — General Purpose W — Heavy Duty	Fixed Q = 44 T = 66 W = 88	BBL	

* 46, 60, 80, 100, 120, 150, 180, 220, 240, 280, 320 (Finer available upon request)
** Concentrations are Fixed in the B7 and BBL Bond System. Concentration and Grade are Dependent Upon Application of Product, i e Light Duty, General Purpose or Heavy Duty (See Grades)
*** When Wheels With a Rim are Used
**** These Wheels are Part of the Toolmaster Program

CBN Type & Application

CBN Type	Grinding Condition
1BN (Nickel Coated)	Wet or Dry
BN (Nickel Coated)	Wet or Dry

Grit Size and Selection Guide

Operation	Grit Size
Roughing and Heavy Stock Removal	80 - 100
Medium Stock Removal, Average Finish	120 - 180
Light Stock Removal, Good Finish	220 - 320
Fine Finishing	400 - 500
Super Finishing	600 & Finer

Recommended Starting Grades For Popular CBN Wheel Shapes

Type of Grinding	Popular Wheel Shapes	Specifications	
		HEAVY DUTY	GEN. PURPOSE
Surface Grinding • horizontal spindle reciprocating table (including broach grinders)	1A1	1BN60-T-B7 1/8	1BN80-T-B7 1/8 1BN80-Q80-B4Y
	6A9, 11V9 6A2-12A2		
rotary table	1A1	1BN60-T-B7 1/8	1BN80-T-B7 1/8 BN100-T-BBL 1/8
• vertical spindle large (usually rotary table)	2A2T, 6A2		1BN46-T-B7 1/8
O.D. Grinding • centertype • centerless	1A1 1A1	1BN80-W-B7 1/8 1BN60-W-B7 1/8	1BN80-T-B7 1/8 1BN120-T-B7 1/8 (Finish)
Slotting (no cutoff)	1A1, 1A1R	1BN100-W-B7 1/4	1BN150-W-B7 1/4
Saw Sharpening • rake • clearance	12A2, 15A2 11V9, 12V9, 15V9	1BN80-W-B7 1/8	1BN100-W-B7 1/8
Small Drill Pointing	2A2, 6A2	1BN80-W-B7 1/8	1BN150-T-B7 1/8
Hob Sharpening (wet only)	1V1, 12V9	1BN80-W-B7 1/16	1BN150-W-B7 1/8
Rotary Burs or Files (machine and offhand grinding)	1V1 1V1	1BN80-W-B7 1/8 1BN100-W-B7 1/8 (Finish)	1BN150-W-B7 1/8 1BN220-W-B7 1/8
End Mill Flute Grinding (wet only)	1A1, 1V1	1BN100-W-B7 1/8 1BN100-Q100-B4Y	1BN180-T-B7 1/8 1BN180-Q80-B4Y
Other Multi-Tooth Cutters and Tools (relieving, backing off and clearing end mills, face mills, reamers, etc)	6A9, 11V9, 12V9, 15V9	1BN150-Q100-B4Y	1BN80-T-B7 1/8 BN150-W-BBL 1/8
Internal Grinding general purpose (wet only)	1A1, 1AS		1BN120-Q100-B4Y

Resin Bonded Diamond Wheels Availability and Markings

Selecting The Wheel Specifications

Wheel Grade
Use the hardest letter grade that can be used without causing heat damage to the wheel or work.

Most diamond applications will be in the N-P-R range.

Concentration
Most diamond applications will be 75-100 concentration. Internal grinding wheels should be 100 concentration and medium-to-hard grades.

Wheel Size
When converting from conventional wheels that grind on the periphery, do not reduce the diamond wheel OD. This reduces SFPM and with it, grinding efficiency.

Wheel Speeds
The best average wheel speed for wet grinding is 5000 to 6000 SFPM for most applications.

In dry surface and cutter grinding, wheel speeds of 4000 to 5000 SFPM give best grinding efficiency.

Speeds of 2500 to 3000 SFPM provide the best results in internal grinding. Using incorrect wheel speeds may reduce wheel life.

Feed Rates
Excessive feed rates cut down on wheel life and should ordinarily be avoided.

Mounting, Trueing & Dressing
For an in-depth explanation, see the section entitled Mounting, Trueing and Dressing.

For assistance on a specific application, contact your local Cincinnati Milacron Grinding System Engineer (GSE).

Grinding Fluid
Diamond wheel grinding should be done with a grinding fluid whenever possible. Synthetic fluids should be used with diamond abrasives.

We recommend Cincinnati Milacron's CIMCOOL® Metalworking Fluids for best results.

CMD 150-R100-B 1/16

Grit Type	Grit Sizes*	Grades	Concentrations**	Bonds	Depth of CBN
MD	46 thru 600**	Soft-J-L-N-P-R-Hard	Low-50-75-100-High	B, BY	
CMD	46 thru 320	J-L-N-P-R	50-75-100	B, BY	
AMD	46 thru 320	J-L-N-P-R	50-75-100	B5, B5Y	***
DMD	60 thru 320	J-L-N-P-R	50-75-100	B6, B6Y	
EMD	60 thru 320	J-L-N-P-R	50-75-100	B, BY	
NCD ****	100, 150, 220	P-R	75-100	BDL	

* 46, 60, 80, 100, 120, 150, 180, 220, 240, 280, 320, 400, 500, 600
** Finer Grit Sizes Available
*** When Wheels With a Rim are Used
**** These Wheels are Part of the Toolmaster Program

Diamond Type & Application

Diamond Type	Material To Be Ground	Grinding Condition
MD (Uncoated)	Carbide With Very Little Amount of Metal	Wet or Dry
CMD (Nickel Coated)	Carbide With Limited Amount of Metal	Wet or Dry
AMD (Copper Coated)	Carbide Only	Dry
DMD (Nickel Coated)	Carbide With Relatively Large Amount of Metal	Wet or Dry
EMD (Nickel Coated)	Carbide Only	Wet
NCD (Nickel Coated)	Carbide with Limited Amount of Metal	Wet or Dry

Grit Size and Selection Guide

Operation	Grit Size
Roughing and Heavy Stock Removal	80 - 100
Medium Stock Removal, Average Finish	120 - 180
Light Stock Removal, Good Finish	220 - 320
Fine Finishing	400 - 500
Super Finishing	600 & Finer

General Resin Bond Diamond Wheel Recommendations

Suggested Specifications For Grinding Cemented Carbides	
Grinding Operations	**Recommended Specifications** (Diamond depth omitted * Usually 1/8")
Chip Breakers	MD150-N100-BY (less than 1/4" thick) MD150-R100-BY (1/4" thick or thicker)
Cutting-Off and Slotting	CMD150-R100-BY
Internal (wet)	CMD150-N100-BY
Lapping	MD400-L50-BY
Multiple Point Tools (Milling Cutter, Reamers, Broaches, Hobs, Saws)	
• Roughing (wet)	CMD100-N100-BY or NCD100-P100-BDL
• Roughing (dry)	AMD100-R100-B5Y
• Finishing (wet)	CMD220-N100-BY or NCD220-P100-BDL
• Finishing (dry)	AMD220-R100-B5Y
Single Point Tools	
• Roughing (wet)	CMD100-N100-BY or NCD100-P100-BDL
• Roughing (dry)	AMD100-N100-B5Y
• Finishing (wet)	CMD220-P75-BY or NCD220-P75-BDL
• Finishing (dry)	AMD220-P75-B5Y
Surface	
• Roughing (wet)	CMD120-N100-BY or NCD100-P100-BDL
• Roughing (dry)	AMD120-N100-B5Y
• Finishing (wet)	CMD240-P100-BY or NCD220-P100-BDL
• Finishing (dry)	AMD240-P100-B5Y
Inserts Wet	
• Roughing	CMD220-P100-BY *CERAMIC INSERTS
• Finishing	CMD400-P100-BY USE "L" HARDNESS

Cincinnati Milacron's sophisticated **SPC Controls** program monitors quality constantly to ensure extremely high product consistency.

The **Products Testing Laboratory** tests new and improved grinding wheels in actual use on machines. Specialists with grinding machine tool industry experience use the latest scientific equipment to evaluate performance and help determine if the grinding wheel is being used to its optimum level.

Finally, before a wheel is released to the field, it is used in demanding production environments in many of Cincinnati Milacron's plants. You never get a Cincinnati Milacron grinding wheel until it is proven in actual use.

Physical Properties

Both Diamond and CBN wheels are ultra hard. Milacron's diamond wheels reach over 7000 on the KNOOP Hardness Scale. By comparison, aluminum oxide and carbide wheels only reach approximately 2100-2400 KNOOP hardness. (Figure 1)

Superabrasives will provide grinding ratios from 100-1000 times higher than conventional abrasives. (Figure 2)

In addition, superabrasives conduct heat better than all other grinding wheel materials. (Figure 3) As they work, they pull heat away from the grind and the workpiece. Conventional abrasives are insulators, forcing heat back into the workpiece.

By increasing quality, overall productivity and reducing wheel wear to a fraction, Diamond and CBN grinding wheels will provide a significant return on investment. There is less scrap, because burn is virtually eliminated. Part quality is consistently higher. And downtime due to wheel changes is drastically reduced. (Figure 4)

When you want greater cost efficiency and need application expertise to help find solutions, count on Cincinnati Milacron Products Division.

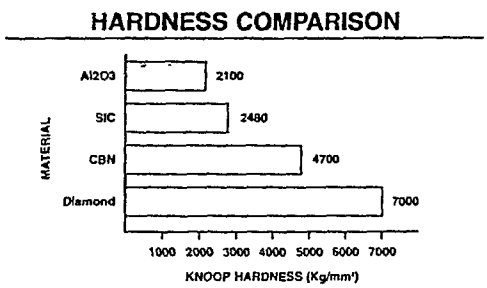


Figure 1

GRINDING RATIO EXAMPLES

WORKPIECE	HARDNESS	AlOx*	CBN**
M-2	60 Rc	4.5	1030
M-4	60 Rc	2.0	180
M-50	60 Rc	—	250
T-15	65 Rc	0.8	120
O-1	62 Rc	50	750
A-2	62 Rc	20	390
D-2	62 Rc	3.0	650
GRAY IRON	32 R_A	—	2700
NODULAR IRON	57 R_A	—	870

*10 IN. DIA. **5 IN. DIA.

Figure 2

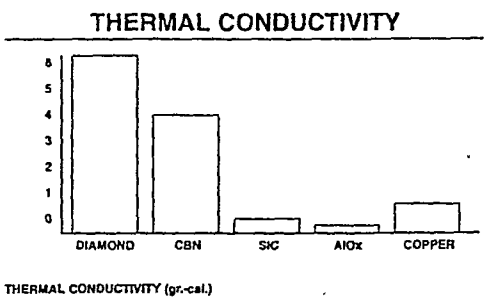


Figure 3

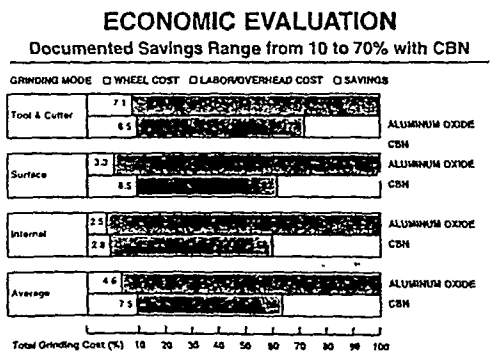


Figure 4

MIL 000267

Mounting, Trueing and Dressing Resin Bonded Diamond & CBN Wheels

NOTE: The techniques for mounting, trueing and dressing resin bond diamond and CBN wheels are the same with the exceptions noted.

Mounting The Wheel

1. The Importance of Care

The care taken in mounting a new wheel the first time always pays off in longer wheel life. The grinding wheel must be in contact with the work across the full width of the wheel face in order to grind at full efficiency. The diamond or CBN rim must be trued and dressed. Thus, every careful attention to attaining perfection in the original wheel mounting operation will minimize abrasive loss due to trueing.

2. Standards

Wheels where the OD is used for grinding should never runout more than 0.0005". Even less runout than this may be required on finish grinding to obtain very fine finishes.

Cup and other "face" grinding wheels should not runout more than 0.001" on the wheel face.

3. How to Mount

Do not use blotters on wheels with aluminoid cores. Always use a dial indicator reading to 0.0001" to check runout and out-of-roundness of the wheel. The arbor holes of CINCINNATI MILACRON diamond and CBN wheels are manufactured with a controlled amount of oversize. This enables the mounted wheel to be adjusted to meet the runout standards. Here is the technique:

a. OD Grinding Wheels

Mount the wheel and tighten the flange nuts only enough to allow for stable repositioning as follows: Check the wheel runout with the indicator. If the runout is too high, the wheel position should be adjusted. Place a wooden or plastic block against the wheel at the point of greatest runout. Gently tape the block with a hammer (see Figure 1). Repeat this process until the runout is minimized and then securely tighten the flanges. (NOTE: Use flanges with the largest diameter possible when mounting diamond cutoff wheels.)

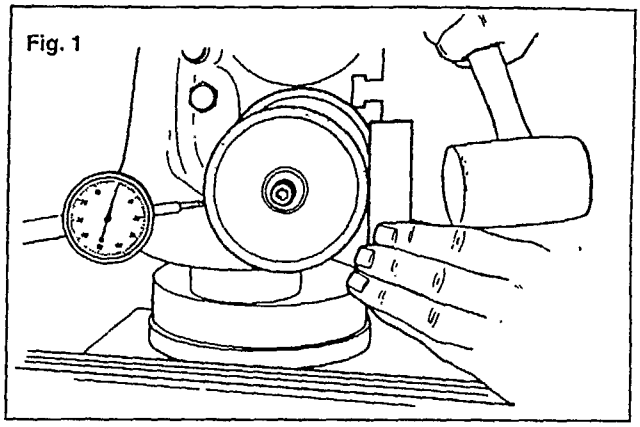


Fig. 1

b. Face Grinding Wheel

Mount the wheel and tighten the flanges securely. Check the face runout with the dial indicator (see Figure 2). If the face runout is too great, loosen the flange and rotate the wheel. Again tighten the flanges securely and again indicate the wheel runout. If repetition of this process does not eliminate the runout, the wheel must be conditioned as described in the next section.

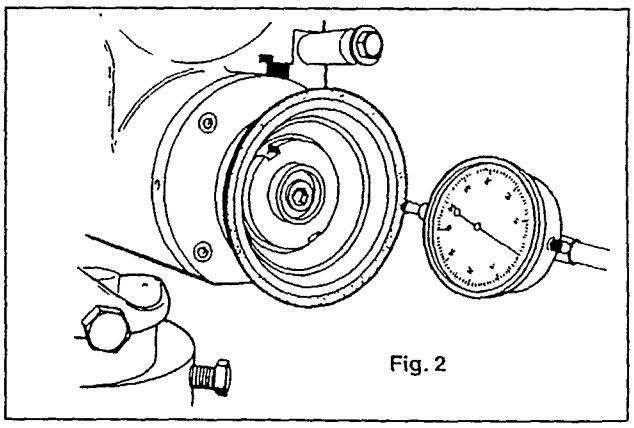


Fig. 2

Trueing and Dressing Vitrified Wheels

Vitrified-bonded CBN wheels do not require a two-step procedure of trueing and dressing provided they are correctly trued with a rotary diamond trueing device. Several types are available, some better than others. Parallel-axis and cross-axis types are available. The key to success is to reduce the amount of contact area between the wheel and the diamond roll without sacrificing excessive diamond wear. Trueing and dressing tools are metal bond or plated diamond wheels which provide the necessary cutting action to remove CBN wheel stock with little or no additional wheel conditioning. It may be necessary to slightly condition or dress the wheel face by grinding at reduced rates for a short time. Whether or not this is necessary depends upon the type and grade of diamond trueing wheel used. Grinding at a reduced rate would only be required after the initial dressing of a new wheel; subsequent in-process trueing will not require this extra step.

Stationary tools which traverse across the face of a vitrified CBN wheel will true it. However, this trueing technique will excessively load and glaze the wheel. A wheel trued in this manner will not grind effectively and needs further conditioning. In production grinding, extra time for conditioning after every in-process trueing operation is not acceptable.

Single-point and impregnated-diamond tools will not efficiently true and dress vitrified CBN wheels for production grinding. These wheels are so hard that when 0.001 inch is dressed from the wheel a like amount can be worn from the dressing tool. Therefore, wheel geometry cannot be accurately assured. Rotary dressers do not wear significantly compared to single-point tools. Reducing grinding wheel speed prior to trueing will enhance CBN wheel material removal, but this isn't always practical.

In order to see the differences between the trueing and dressing procedures of resin-bonded and vitrified-bonded CBN wheels, let's examine the start-up procedure for a vitrified-bond CBN wheel on an internal grinder.

When a new wheel is placed on the machine it should be lightly covered with a marking medium such as a china marker or crayon. This helps the operator see when the diamond dresser touches the wheel. The initial dress-off should be made in increments of 0.0002 inch on diameter per pass of the rotary dresser. The trueing should stop as soon as the diamond dresser completely touches all across the wheel. Traverse the diamond dresser at the rate of 0.001 to 0.002 inch lead per revolution of the grinding wheel. Trueing should not be continued to remove traces of the marking medium that may be in the pores of the wheel. To insure that the wheel is trued, it is best to check by grinding a few parts.

After the truing procedure is completed, the wheel will have a silky, smooth appearance. The wheel is now very dull but is ready for grinding. Initially, it will not cut efficiently because of excessive contact with the diamond roll. Start grinding at about half the normal rate to allow the wheel to open up and thus eliminate the possibility of overloading the wheel. This process is called the "conditioning cycle". As the wheel becomes conditioned, the grinding rate can be increased until the optimum cycle time is reached. This conditioning process can be reduced or completely eliminated with the use of an open structure vitrified bonded CBN such as MARATHON 2.

After the wheel is sharp and open, and the grinding cycle has become stabilized, the skip dress counter for in-process dressing may be raised or lowered depending on the wheel performance. For example, it may be set for dressing after every 50 parts are ground. In any event, the dressing tool in-feed compensation should be kept at 0.0001 inch or less. This small increment of dress will not affect the cutting efficiency of the wheel between dress cycles. The grinding cycles need not be reduced.

Every time a new wheel is put on the grinding machine, the same start-up procedure should be followed. The extra five to ten minutes consumed by this procedure will be offset by the extremely long-life of vitrified CBN wheels. Except for this initial wheel trueing/dressing procedure, the production and dressing cycles can be made fully automatic.

Wheel Conditioning

The condition of the working face of a diamond or CBN grinding wheel will greatly affect its grinding performance. The wheel surface condition, along with wheel speed and feed rates, can determine the success of failure of any correctly graded and correctly mounted wheel. The grinder operator will control the condition of the grinding surface by trueing, dressing and (when needed) core relieving.

NOTE: Never attempt to true or dress a diamond or CBN wheel with a single point diamond. Serious damage will result to both. Also whenever possible, use a grinding fluid when trueing a wheel.

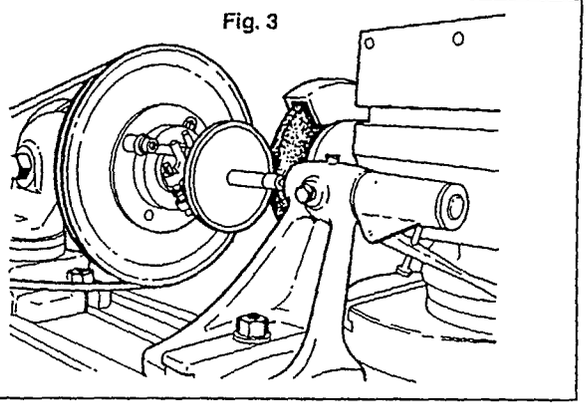
Always true a wheel to make it concentric with the spindle and to give the desired wheel geometry.

For diamond OD grinding wheels, use the following methods: (1) is preferred, then (2) or (3).

For CBN OD grinding wheels, use methods (1), (2), or (3), or use a diamond impregnated tool (metal bonded particle diamond), about 80-150 mesh.

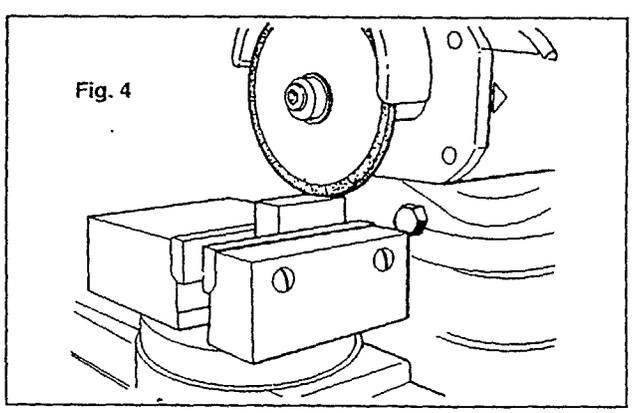
1. Trueing
   a. OD Grinding Wheels
      (1) Mount a brake type dresser on the grinder. Brake true wheel grades are as follows:
      For Diamond Wheels - 6C120-M6-VSC
      For CBN Wheels - 9A120-M6-VFM
      (2) Remove the diamond or CBN wheel and mount from the grinder. Place the wheel mount on a special mandrel having a taper that fits the taper of the wheel mount. Place this assembly on a cylindrical grinder or on a lathe that has a mounted tool post grinder. If the special tapered mandrel is not available, the diamond or CBN wheel may be remounted on a standard flange and nut type mandrel for trueing. This technique, however, will require very careful remounting of the trued wheel to avoid runout. True the diamond or CBN wheel with a silicon carbide or aluminum oxide wheel as recommended in (1). The trueing wheel and diamond or CBN wheel must rotate in opposite directions. The rotational speed of the diamond or CBN wheel should be reduced (if possible) to no more than ¼ of its normal operating speed.

Fig. 3



(3) Mount a standard dressing stick or a piece of mild steel on the grinder (see Figure 4). Grind a small amount off this workpiece using 0.001" maximum feed per pass. Although time consuming, this technique will ultimately true the wheel.

Fig. 4



2. Dressing

Correctly graded resin bond diamond wheels operated in the correct manner will require very little dressing. Wheel dressing removes bond material to expose the sharp cutting edges of the abrasive crystals. The wheel surface is lightly scrubbed with a soft, fine abrasive dressing stick to remove glaze and load (see figure 5). Some of the resin bond is removed during dressing. This leaves the diamond abrasive grits protruding from the remaining bond to provide a sharp, cool cutting wheel. Diamond wheels should be dressed only when needed. Excessive dressing may prematurely remove partially worn diamond grains. Dressing is needed after trueing because trueing glazes diamond wheels.

Diamond Stick Recommendation — 9A220-G4-V9468

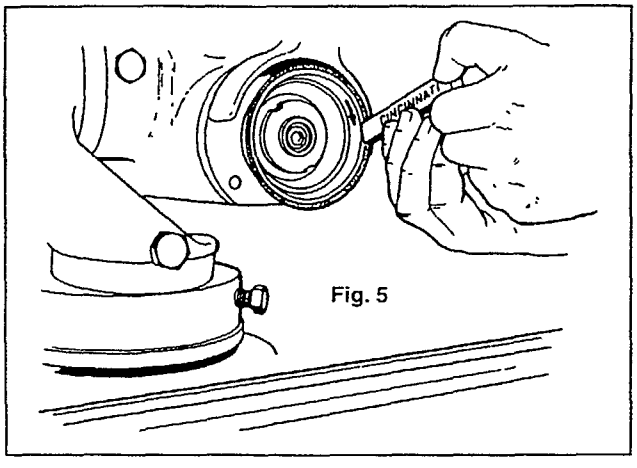


Fig. 5

3. Core Relieving

Core relieving is required on some diamond wheel shapes. Whenever the core material makes contact with the workpiece, it must be relieved. For example, the core area adjacent to the rim on a cup wheel will start to rub on the workpiece as the diamond rim wears down. This core material must be removed to restore the diamond cutting area to top efficiency. This core removal or relieving must be done on all diamond wheels of this type, regardless of what the core material is. If the core is not relieved, the wheel grinding face will load. A loaded wheel face has a reduced cutting and finishing efficiency and will cause smearing of the ground surface. Further, the rubbing of an unrelieved core creates frictional heat which will quickly result in wheel failure and damage to the part being ground.

The core relieving operation on all core materials must be performed with a lathe type carbide or HSS cutting tool (see Figure 6). A dressing stick should never be used for core relieving, as it may cause serious damage to the wheel. The damage results from the intense frictional heat and high contact pressure necessary with a dressing stick — this can cause the core to become permanently distorted.

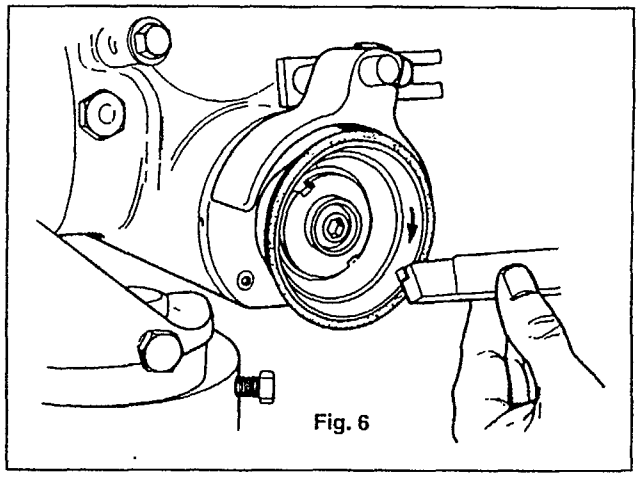


Fig. 6

Applications Leading the Way

- Production I.D. grinding
- Creepfeed grinding
- Cam lobe and crankshaft grinding
- Cylindrical grinding of fuel injection components
- Centerless grinding
  - Needle bearings
  - Engine valves
  - Camshaft main bearings

MARATHON™ 2 Case History I

Industry:	Automotive
Part:	Engine Valve
Material:	Steel
Operation:	Stem and seat grind
Wheel grade:	Seat — 2BN120-0164-VMB Stem — 2BN150-M164-VMB
Wheel Size:	Stem — 18 x 4,500 x 12 Seat — 17.250 x .280 x 12
Machine:	Cincinnati 2-250 Centerless
Metalworking Fluid:	2AXJ-3 @ 5%
Dressing System:	Diamond Roll

Advantages:
- Seat roundness 1.5 um
- Stem roundness .30 um
- Straightness .3 um
- 800 parts per dress on seat grind
- Cycle time reduced to 6 seconds (stem only 2.55)
- 1000 part per dress on stem and higher wheel speed could push to 4,000

MARATHON™ 2 Case History II

Industry:	Automotive
Part:	CVJ Component
Material:	8620 55RC
Operation:	Track grind
Wheel grade:	2BN80-K100-VMC
Wheel Size:	.722 x .832 x .354
Machine:	Excello
Metalworking Fluid:	Oil
Dressing System:	Diamond Cup

Advantages:
- Increase skip dress from 6 to 12
- Reduced compensation from 5 microns to 3 microns
- Increased feed rate to 350 degrees per minute @ 120%

MARATHON™ 2 Case History III

Industry:	Automotive
Part:	Camshaft
Material:	Steel 58RC
Operation:	Lobe grind
Wheel grade:	2BN100-N164-VMB
Wheel Size:	17.700 x .748 x 12.050
Machine:	Landis
Metalworking Fluid:	Semi-synthetic
Dressing System:	Diamond Roll

Advantages:
- Increased camshafts per dress from 50 to 130
- Eliminated any trace of burn
- Produced more consistent finish and overall quality

MARATHON™ 2 Case History IV

Industry:	Automotive
Part:	Drive shaft component
Material:	5150 56-60RC
Operation:	Slot grind
Wheel grade:	2BN120-N164-VMB
Wheel Size:	16 x 1 x 8
Machine:	ABA Creep Feed Grinder
Metalworking Fluid:	Cimperial 1011
Dressing System:	Diamond Roll

Advantages:
- Removed material in a single pass .400 wide x .468 deep
- Q′ = 22 in³/min/in
- Grinding time less than 5 seconds

MARATHON™ 2 Case History V

Industry:	Bearing
Part:	Cone
Material:	52100 58-62RC
Operation:	I.D. grind
Wheel grade:	2BN120-Q164-VMB
Wheel Size:	1.250 x .812 x .500
Machine:	Heald ICF
Metalworking Fluid:	Soluble Oil
Dressing System:	Diamond Cup

Advantages:
- Increased wheel life from 200 ppw to 27,000
- Improved CR on ID side and taper
- Reduced wheel changes from 1250 to 9
- Reduced machine idle time from 155 hours to 4 hours
- 1 operator for 8 machines

VIDA

Abrasive product which combines the superior properties of diamond and Milacron's patented vitrified bonding technology.

I. Current Markets

Carbide Tools, Drills, End Mills
Polycrystalline Diamond and CBN (PCD, PCBN)
Cermets
Composites

II. Developing Markets

Engineered Ceramics
Types of Ceramic
Alumina
Zirconia
Silicon Nitride
Silicon Carbide

III. Ceramic Components

Bearings - Ball Bearing
Tools - Inserts
Engine Components - Valves, Cam followers, Spring Guide
Heat Exchangers
Biomedical
Electronic - Magnetic Heads, Substrates, Semiconductors

Advantages of Vitrified Diamond

- VIDA contains porosity or chip clearance unlike resin or metallic bonds
- Cooler grinding
- Lower HP consumption (See chart I)
- Higher grinding ratio (See chart I)
- Reduced conditioning required. Some grades eliminate conditioning all together

Product Definition

- Grading System — RD100-O100-VDA
  - Grain Type: RD (Uncoated)
  - Grain Size: 60-320 (Finer requires lab #)
  - Hardness: M, N, O
  - Concentration: 50, 75, 100, 125
  - Bonded Designation: VDA

Vitrified Diamond Abrasive

Typical Marking RD280-N75-VDA 1/8

GRIT TYPE	GRIT SIZE	GRADES	CONCENTRATION	BOND
RD	60-320	M, N, O, P, Q	50, 75, 100	VDA
	>320 w/code		125	
	number			

Diamond Depth

MIL 000273

Grade Selection

A. Grain-RD — uncoated grain

B. Mesh Size

Roughing and Heavy Stock Removal (.015-.020) 120-150
Medium Stock/Average Finish — 16RA — 180-220
Light Stock/Good Finish — 10-12RA — 240
Fine Finishing 6-10 RA — 400-600
Super Edge Quality, Fine Micro 600-1200 (PCD Tools)

C. Wheel Grade

Available Range = soft M, N, O, P Hard
The trend is O and P hardness for most tool grinding.

Considerations

- Large Contact Areas (O.D.) grinding
- Wet or Dry Grind; Wet, Harder — Dry, Softer
- Wheel Speeds

D. Concentration

Availability: 50, 75, 100, 125
- PCD Tools — 100, 125
- Internal — 50-75
- Surface — 75
- Cylindrical — 75-100

Light Stock — 50 conc.
Medium — 75 conc.
Heavy Stock — 100, 125 conc.

E. Bond Designation

VDA — Used on all applications
Mesh size finer than 320 requires an NPI form be submitted (New Product Inquiry)

F. Depth of Diamond

Internal — 1/8
Cylindrical — 1/8
Surface — 1/8
PCD Tools — 3/8

Application Considerations

Application

— Surface Grind
— Internal
— Cylindrical
— Side/Face Grinding

Key Elements

Surface

Contact area, wheel speed (4500-6000 SFPM), stock removal, depth of cut (.0002-.0005) surface finish.

Internal

Wheel conformity, wheel speed, stock removal, surface finish.

Cylindrical

Part diameter, part length, wheel speed, pickfeed amount (.0002-.0005) traverse speed.

Side & Face Grind (Type 2 & 6)

Area of part to grind, desired tool geometry normally finer mesh 240-600, PCD Tools 600-1200.

Types Availability

VIDA products are available in the following shapes and sizes:
1A1 1A1 specials
1A8 6A2
6A2C-6A2H, and other similar facing wheels (i.e. 4A2, 12A2, etc.)

Sizes
Diameter .250 — 24"
Thickness .250 — 1, >1 available in multiple 1 sections.

Core Materials

Ceramic
Aluminum
Steel

Diamond Depths

1/16, 1/8, 1/4, 3/8

Grading System

Grain Type — RD
Mesh Size — 60-1500 finer than 320 requires a code number
Hardness — M, N, O, P
soft ◄——► hard
Structure — Standard structure is 9
Concentration — 50, 75, 100, 125
Bond Designation — VDA

Material/Industry

A. Non-Ferrous Materials

- Carbides
- Ceramics — 4 types: industrial, technical, electrical, advanced
  - Silicon Nitride
  - Silicon Carbide
  - Alumina
  - Zirconia
- Composites
- PCD — Polycrystalline Diamond Tools
- Plasma Sprays
- Aluminum

MIL 000274

BY Bond

A. Definition
BY Bond is an epoxy modified resin which is more forgiving and can withstand higher grind temperatures.

B. Advantages
Can be used with diamond or CBN
Extends wheel life of our resin bonded products by 30% (minimum)
More consistent resin in terms of wheel to wheel and start to stub
In some cases BY Bonds have been more cost effective than polyimide resins
BY Bond is priced as a standard resin

Availability

- Diamond (All bond systems)
- CBN (B4 system only)

How to Specify

- Use the letter "Y" to designate

Example:

Standard Grade	Modified Resilient Resin
CMD120-R100-B 1/8	CMD120-R100-BY 1/8
IBN150-Q80-B4 1/8	IBN150-Q80-B4Y 1/8

BY System (Epoxy Modified Resin)

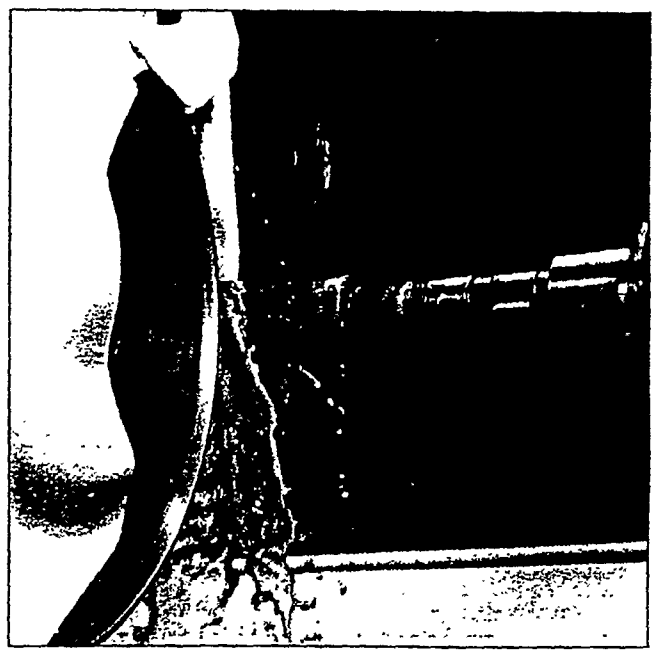
Advantages

- Better life
- Higher heat resistance
- More resilient
- Extended wheel life
- Less grinding pressure
- Better form holding

Applications of Resin Bonds

A. Diamond — Grinding of non-ferrous materials
Carbide tipped saw grinding
Carbide insert grinding
Carbide tools; drills, end mills, reamers
Plasma spray coatings
Ceramic - roughing
Glass grinding

B. CBN — Grinding of ferrous materials
HSS tools; end mills, drills, reamers
Huffman, Walter, Star CNC Grinders
Surface grinders



MIL 000275

CIMFORM GRINDING WHEELS
SUPERABRASIVE MARKING CHARTS

RESIN BOND DIAMOND WHEELS

GRIT TYPE		GRIT SIZES	GRADES	CONCENTRATIONS	BOND	DEPTH OF DIAMOND
MD	Uncoated	46 thru 600	Soft-J-L-N-P-R-Hard	Low-50-75-100-High	B, BY	
CMD	Nickel Coated	46 Thru 320	J-L-N-P-R	50-75-100	B, BY	
AMD	Copper Coated	46 thru 320	J-L-N-P-R	50-75-100	B5, B5Y	****
DMD	Nickel Coated	60 thru 320	J-L-N-P-R	50-75-100	B6, B6Y	
EMD	Nickel Coated	60 thru 320	J-L-N-P-R	60-75-100	B, BY	
NCD	Nickel Coated	100, 150, 220	P-R	75-100	BDL	

RESIN BOND CBN WHEELS

GRIT TYPE		GRIT SIZES	GRADES	CONCENTRATIONS	BOND	DEPTH OF DIAMOND
1BN	Nickel Coated	46 thru 320	Soft-M-O-Q-S-U-Har	Low-80-100-High	B4, B4Y	
1BN	Nickel Coated	46 thru 320	Q - Light Duty T - General Purpose W - Heavy Duty	Q=44 T=66 W=88	B7	****
BN	Nickel Coated	100, 150, 220	Q - Light Duty T - General Purpose W - Heavy Duty	Q=44 T=66 W=88	BBL	

VITRIFIED BOND DIAMOND WHEELS

GRIT TYPE	GRIT SIZES	GRADES	CONCENTRATIONS	BOND	DEPTH OF DIAMOND
RD	60-320	M-N-O	50-75-100	VDA	****

VITRIFIED BOND CBN WHEELS

GRIT TYPE		GRIT SIZES	GRADES	CONCENTRATIONS	BOND	DEPTH OF DIAMOND
2BN	Uncoated	60 thru 320	P-R-T-U	100-125-150	VHA	****
2BN	Uncoated	60 thru 320	P-R	100-125-150	VHC	

VITRIFIED BOND OPEN STRUCTURE CBN WHEELS

GRIT TYPE		GRIT SIZES	GRADES	CONCENTRATIONS	BOND	DEPTH OF DIAMOND
2BN	Uncoated	60 thru 320	M-N-O-P	80-100-125-150	VEA	
2BN	Uncoated	60 thru 240	M-N-O	100-125-150	VEC	
2BN	Uncoated	60 thru 320	M-N-O-P	164	VEB	****
2BN	Uncoated	60 thru 240	M-N-O	100-125-150	VMA	
2BN	Uncoated	60 thru 240	M-N	100-125-150	VMC	
2BN	Uncoated	60 thru 240	M-N-O	164	VMB	

20 Grinding Wheel Recommendations

Throughout this general wheel rcommendation section we have predominantly recommended our VFM bond where precision vitrified bonded wheels were applicable in alumimum oxide grain.

Where conditions prevail that will allow you to fine tune your setup to get the most out of your grinders, such as parts per dress, faster grinding cycles, better form holding, etc., we recommend that you investigate the use of our premium VRW SUPER CIMFORM bonded wheels to increase your productivity.

Also available (not premium priced) is our VQC bonded wheel. This wheel is available in most popular sizes, grain types, and grades. It has shown improvement in part quality without fine tuning any setups and the most popular sizes are readily available from stock.

Consult your Cincinnati Milacron Marketing Company Products Division Representative to apply our finest product to your most complex grinding job.

Cincinnati has a group of Abrasive Application Engineers and Account Service Specialists who specialize in abrasive applications. Whether it is a new job or material, or you want to improve the wheel grade currently used, if you can supply the following information we can help solve your problems.

CUSTOMER name, location

OPERATION - centerless, centertype, internal, etc.

MACHINE - manufacturer and horsepower

WHEEL TYPE AND SIZE

WHEEL SPEED - SFPM

WHEEL GRADE - full grade of present wheel

PART DESCRIPTION - brief

PART MATERIAL - metal type

PART SURFACE - to be ground; give diameter, length, etc.

PART HARDNESS

STOCK REMOVAL on outside diameter

FINISH REQUIRED

GRINDING TIME - cycle time or feed rate

DRESSER TYPE, e.g. single point diamond, cluster, etc.

REASON FOR DRESSING - e.g. maintain size, finish, etc.

PIECES PER DRESS with present wheel

CUTTING FLUID used, oil or water based

NOQ - customer Normal Order Quantity

Call Cincinnati, Ohio - (513) 841-8721 or 841-8250

Alnico	
Cylindrical	97A541-L4-VFM
Surfacing	9A60-H6-VFM
Cutting-off (wet)	2A80-L-R
Cutting-Off (dry)	97A601-L9-B90
Disc-Wet	97A601-H9-B90
Centerless	97A601-K6-VFM
Internal	9A60-J6-VFM
Aluminum	
Cylindrical	9A46-I6-VFM
Centerless	9A46-L6-VFM
Surfacing	6C36-J6-VSC
General Reinforced Cut-Off	
Less than 16"	2A24-P7-BF9
16" and over	2A24-R7-BF9
Surfacing (Discs)	6C24-J9-B90
Internal	6C46-K6-VSC
Bars	
Cutting-off (dry)	2A24-Q9-B2S
Cutting-off (wet)	2A46-P-R
Aluminum Castings	
Disc	
Small - light work	C2A361-J9-B90
Large - heavy work	C2A241-L9-B90
Surfacing	
Cylindes, cups, segments	12A30-G10-VA
Aluminum Plate	
Surfacing -	
Cylinders, cups, segments	6C24-F10-VSC
Armatures (Laminations)	
Cylindrical - roughing	9A60-I6-VFM
- finishing	9A120-I6-VFM
Internal	97A461-J6-VFM
Asbestos - Cement Products	
Cutting-off	6C24-O9-B90S
	6C24-T7-BF9
Asbestos Clutch Facings	
Disc	6C24-J9-B90
Balls for Bearings	
(Large)	
Semi-finishing	97A801-J6-VFM
(Small)	
Semi-Finishing	97A1201-L4-VFM
Final Finishing	97A1501-L4-VFM
Ball Bearing Races	
Disc Surfacing outer and inner races - soft	97A461-J9-B90
Disc Surfacing outer and inner races - hard	97A801-F9-B90
Grind O.D. cups - roughing and finishing	97A601-L6-VFM
internal	
Grind outer race (form)	97A1201-L6-VFM
Grind outer race (oscillating)	
Wheel diameter 1/4 - 7/8"	97A1001-L4-VFM
Wheel diameter 1 - 3"	97A1001-K6-VFM
Wheel diameter 3" - up	97A1001-J6-VFM

Grind inner race (form)	
Grind inner race (oscillating)	97A1001-K4-VFM
Internal grind bore	
Bars (Centerless)	
Hard or soft steel	
3/4" and smaller	97A541-S9-B90
3/4" to 2-1/2"	97A541-R6-B90
over 2-1/2"	97A541-Q9-B90
Aluminum, some tool and stainless steels	C2A541-Q9-B90
Steels tubing	97A601-Q9-B90
To achieve a commercial or better finish	97A801-Q9-B90
Bearings (Centerless)	
Pins (straight) up to 1/8" O.D.	
Roughing	12A80-S7-B90
Finishing	C12A1001-T6-B90
Pins (straight) over 1/8" O.D.	
Roughing	12A60-Q9-B90
Finishing	2A100-R6-B90
Races O.D. (roughing and finishing)	
3" dia. and less	12A60-M6-VFM
over 3" dia.	12A60-K6-VFM
Rollers (straight)	
Roughing	12A60-L6-VFM
Finishing	97A1001-M4-VFM
Rollers (tapered)	97A1001-M4-VFM
Boron Carbide (Norbide)	
Cylindrical	
Roughing	CMD100-L100-B
Semi-finishing	CMD220-L100-B MD320-L100-B
Finishing	MD400-L100-B
Cutting-off (1A1R)	CMD100-N100-B
Internal Grinding	
Roughing (1A1, 1A8)	CMD100-N100-B
Finishing (1A1, 1A8)	CMD320-N100-B
O.D. Grinding	
Roughing (1A1)	CMD100-L100-B
Semi-finishing (1A1)	CMD200-L100-B
Finishing (1A1)	MD320-L100-B
Surface Grinding	
Roughing (1A1, 2A2, 6A2)	CMD100-N100-B
Finishing (1A1, 2A2, 6A2)	MD320-L100-B
Bolts (Screws and Studs)	
Cylindrical	12A60-K4-VFM
Centerless	12A60-M6-VFM
Brake Lining (Molded)	
Surfacing (Discs) roughing	6C24-M9-B90
Surfacing (Discs) finishing	6C36-L9-B90
Surfacing (Drum Type)	6C46-L9-B90
Cutting-off (dry)	6C30-Q9-B90
Brake Lining (woven)	
Surface (discs)	6C24-L9-B90
Brake Drums (automotive)	
Regrinding	97A461-K4-VFM
Brake Shoes (railroad) chilled iron	7C241-P9-B90

Brass	
Centerless	6C36-L6-VSC
Cylindrical	6C36-K6-VSC
Internal	6C60-L6-VSC
Surfacing	
Type 1 Wheel	6C36-J6-VSC
Cylinders, cups, segments	6C24-H6-VSC
Surfacing (discs)	6C24-J9-B90
Cutting-off rod (dry)	
9000-16000 SFPM	2A24-T7-B90S
Cutting-off rod (wet)	
7500-12000 SFPM	2A46-N-R
Cutting-off tubing (wet)	
9000-16000 SFPM	2A120-P-R
Cutting-off tubing (dry)	
7500-12000 SFPM	2A80-P-R
Brass Rod	
Cutting-off (dry)	2A24-T7-B90S
Cutting-off (wet)	2A46-N-R
Brass Tubing	
Cutting-off (dry)	2A80-P-R
Cutting-off (wet)	2A120-P-R
Brick (Vitrified)	
Cutting-off (dry)	6C24-O9-B90S
Cutting-off (wet)	6C24-P7-BF9
Surface (cups and cylinders)	6C24-N6-VSC
Surfacing (discs) hard	6C24-L9-B90
Surfacing (discs) refractory	6C24-K9-B90
Broaches	
Sharpening	9A60-K4-VFM
Bronze (soft)	
Use same wheels as for brass	
Bronze (hard)	
Centerless	9A46-M4-VFM
Cylindrical	97A461-M4-VFM
Internal	97A601-L4-VFM
Surfacing (cylinders, cups, segments)	9A36-G10-VA
Surfacing - (type 1)	97A361-J6-VA
Surfacing (discs)	C2A241-K9-B90
Bushings (Hardened Steel)	
Centerless	12A60-L6-VFM
Cylindrical	9A60-L4-VFM
Internal	9A60-K4-VFM
Bushings (Centerless)	
Bronze	6C46-Q4-VSC
Bushings (Cast Iron)	
Cylindrical	6C46-K6-VSC 6C46-J6-VSC
Internal	9A60-K4-VFM
Toolroom	9A60-H6-VFM 5C60-I6-VSC
Surface (dry)	12A46-H6-VA
Surface (wet)	12A60-I6-VA
InternaL (wet)	12A60-K6- VA

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CPM 10-V	
Toolroom	9A60-H6-VRW
	5C60-J6-VSC
Surface (dry)	9A46-H6-VFM
Surface (wet)	1BN100-T-B7
Internal	1BN100-Q100-B4
Cable (Steel)	
Cutting-off (dry)	2A24-V7-B90S
Camshafts	
(See Cam Grinding in Centertype Product Application and Selection Section)	
Carboloy	
See Diamond and CBN Section	
Carbon	
Surfacing	6C24-I6-VSC
Surfacing (discs)	6C24-I9-B90
Surfacing Fine Finish	6C100-I9-B90
Carbon (Metallic)	
Cutting-off (dry)	6C24-O9-B90
Carbon (Soft)	
Surfacing	6C46-I6-VSC
Cutting-off (dry)	6C60-N9-B90S
Cutting-off (wet)	6C36-K9-B90S
Carbon (Hard)	
Centerless	6C46-L6-VSC
Cutting-off (dry)	6C60-N9-B90S
Cutting-off (wet)	6C46-K9-B90S
Cartridge Dies (Internal)	
Tungsten Steel	
Roughing	5C80-J6-VSC
Finishing	5C120-I6-VSC
Cast Iron	
Centerless	6C46-L6-VSC
	12A54-K6-VFM
General Reinforced Cut-Off	2A24-R7-BF9
	2A24-V7-BF9
Internal	9A60-J6-VFM
Surfacing	
(cylinders, cups, segments)	
Ductile	97A301-F10-VFM
Gray	97A301-F10-VFM
Chilled	6C30-H6-VSC
Ni Hard	9A36-F10-VFM
Surfacing (disc)	C2A24-I9-B90
Cemented Carbides	
Single-point tools, offhand	
Cup or plate mounted wheels	
Roughing (wet or dry)	CMD100-R75-B
Semi-finishing	5C100-H6-VSC
General Purpose	MD120-P75-B
Roughing (wet or dry)	5C60-I6-VSC
Semi-finishing (wet or dry)	5C80-I6-VSC
Single-point tools	
Roughing and finishing (wet)	5C80-J6-VSC

Chip Breaker Grinding	
Less than 1/4" thick	MD150-R100-BY
1/4" and thicker	MD150-N100-BY
Milling Cutters, Reamers, etc.	
Backing-off, Cup Wheel	
Roughing (type 11V9)	CMD100-R75-BY
Finishing (type 11V9)	CMD180-R75-BY
Combination	CMD150-R75-BY
General Purpose	
(type 11V9)	CMD120-R75-BY
(type 12A2)	CMD120-N75-BY
Surface Grinding Straight Wheels	
Roughing (wet)	CMD100-P100-BY
Finishing (wet)	CMD220-P100-BY
General Purpose (wet)	CMD120-N100-BY
Cylindrical Grinding	
Roughing (wet)	CMD100-R75-BY
Finishing (wet)	CMD220-N75-BY
Internal	
Roughing	CMD120-N100-BY
Finishing	CMD220-N100-BY
Centerless	CMD120-R50-BY
Lapping	
Cup Wheel (wet)	MD400-L50-BY
Cutting-off	CMD100-R100-BY
Chasers (Thread)	
Surfacing (cup wheels)	9A46-K6-VFM
Surfacing (straight wheels)	9A60-J6-VFM
Grinding Throats	9A80-K6-VFM
Chain Saw Blades	
Disc	97A461-K9-B90
Chilled Iron	
Surfacing	6C36-I6-VSC
Chisels (Woodworking)	
Sharpening	9A60-K4-VFM
Chrome Plating	
Internal	
Small Parts	9A100-K4-VFM
Large Parts	9A80-I6-VFM
Surfacing (Type 1 Wheel)	9A80-I6-VFM
Cylindrical	
Commercial Finish	9A60-J6-VFM
Good Commercial Finish	12A150-K4-VFM
High Finish	7C220-J9-B90
Clutch Plates	
Discs	2A36-J9-B90
Colomony	
Internal	6C80-I6-VSC
Cylindrical	5C60-K6-VSC
Centerless	6C54-M6-VSC
Colomony	
Surface	
Straight wheel	5C46-J6-VSC
Vertical spindle	5C46-I6-VSC
Columbium	
Cylindrical	9A60-K6-VFM
Surfacing	97A461-J6-VFM

Commutators (Copper)	
Roughing and Finishing (wheel)	6C60-J9-B90
Concrete	
Cutting-off	6C24-T7-BF9
Discs	6C24-J9-B90
Connecting Rods (automotive)	
Internal	97A801-J4-VFM
Surfacing (discs)	97A461-I9-B90
Discs	97A361-I9-B90
Copper	
Cylinder	6C60-K6-VSC
Surfacing (cups and cylinders)	6C24-J6-VSC
Surfacing (discs)	6C24-I9-B90
Cutting-off	
Rod (dry)	2A46-P-R
Rod (wet)	2A60-N-R
Tubing (dry)	2A80-Q-R
Tubing (wet)	2A120-P-R
Gates and Risers (dry, tabor)	
Reinforced resinoid	
Mach. 16000 SFPM	2A24-V7-BF9
Core Files (Silicon Carbide)	
1" x 8"	
1" x 10"	6C24-J6-VSC
1½" x 12"	
Cores (sand)	
Cutting-Off	6C24-O9-B90
Cork	9A24-H6-VFM
	9A24-F10-VFM
Crankshafts	
(See Crankshaft Grinding in Product Application and Selection Section)	
Cutlery	
Knives - Butcher	
Hemming and Klotz Machines	
Carbon Steel & Stainless Steel	97A801-E10-VA
Surface	
Surfacing Sides	9A100-I6-VA
Sharpening (Production)	9A100-I6-VA
Knives - Kitchen	
Hemming Machine	
Carbon Steel & Stainless Steel	9A100-G6-VA
Hollow Grinding	9A100-G6-VA
Knives - Pocket	
Hemming Machine	
Carbon Steel & Stainless Steel	97A120-H6-VA
Knives - Table	
Hemming Machine	
Stainless Steel	97A120-H6-VA
Cutters	
(also see Tool Room Grinding in Product Application and Selection Section)	
Sharpening (Machine)	9A46-K6-VFM
Cutters (Molding)	
Sharpening (offhand)	2A60-N4-VFM

Cylinders,	
Automotive (cast iron) internal	
Regrinding (wheels)	6C36-H6-VSC
	6C46-G10-VSC
Commercial Finish	6C120-L6-VSC
Mirror Finish	7C220-J6-VSC
Cylinders (Aircraft) Internal	
Molybdenum Steel	
Roughing	97A461-J4-VFM
Finishing	9A60-I4-VFM
Regrinding	97A541-I4-VFM
Nitrided	
Before nitriding	6C60-I4-VFM
After nitriding	97A541-J4-VFM
Regrinding	6C60-J4-VFM
Dies (Blanking & Drawing) internal	
Carbon Steel	97A601-K4-VFM
High Carbon, High Chrome	9A80-K6-VFM
Dies (Forging)	
(See Mounted wheel Section)	
Dies (Drawing)	
Surfacing (hardened)	9A60-F10-VFM
	9A46-H6-VFM
Fast Traverse (wet)	9A60-I6-VFM
Cup Wheels (wet)	9A46-G6-VFM
	97A461-I6-VFM
Discs	97A461-I9-B90
Segments	97A461-G6-VFM
Surfacing (Annealed)	
Straight Wheels (dry)	9A46-I6-VFM
Cup Wheels (wet)	9A24-H6-VFM
Discs	97A301-I9-B90
Segments	97A241-H6-VFM
Drills (Manufacturing)	
Cutting-off Soft (wet)	2A46-R-R
Cutting-off Soft (dry)	2A34-V6-B90S
Cutting-off Hard (wet)	2A60-N-R
Cutting-off Hard (dry)	97A461-P9-B90S
Cylindrical	97A601-M4-VFM
Centerless (soft)	2A60-M6-VFM
Centerless (hard)	12A60-M6-VFM
Precision Sharpening	97A461-L4-VFM
Fluting	12A100-S7-BHQ
Pointing	
1/2" and smaller	97A801-P9-B90
Larger than 1/2"	2A80-O9-B90
Grinding Relief	
1/2" and smaller	97A541-M4-VFM
Larger than 1/2"	97A361-L4-VFM
Drills (Salvaging)	
Cutting-off (small)	2A60-M9-B90
Cutting-off (large)	97A601-O9-B90S
Drills (Resharpening)	
1/4" and smaller - machine	9A100-I6-VFM
1/4" and smaller - offhand	2A80-L4-VFM
1/2" to " - machine	97A461-L4-VFM
1/2" to 1" - offhand	97A601-L4-VFM
1" and larger - machine	9A46-H10-VFM

Ductile Iron	
General Reinforced Cut-Off	
Less than 16	2A24-T7-BF9
16 and over	2A24-V6-BF9
Duralumin (Tubing)	
Cutting-off (dry)	2A60-W-R
Cutting-off (wet)	2A80-W-R
Ebonite	
Cutting-off (dry)	6C30-M9-B90
Fasteners (steel centerless)	97A801-M6-VFM
Fasteners (Steel)	
Centerless	97A801-M6-VFM
Regulating Wheels	
(See Centerless Grinding Section)	
Ferrotic	
Cylindrical	97A601-K4-VFM
Surface	9A60-I6-VFM
Internal	9A80-J6-VFM
Hardened State	CMD100-R100-B
Fiber Board	
Cutting-off	6C36-J9-B90
Fiberglass	
Cutting-off	6C36-J9-B90
Fiberglass Insulating Board	
Cutting to size	6C36-J9-B90
Fiberglass Rods	
Cylindrical (dry)	6C46-I10-VSC
Fiber Tubing	
Cutting-off	6C46-K9-B90
Fiber	
Surfacing (discs)	6C24-J9-B90
Cutting-off (board)	6C24-K9-B90
Flute Grinding	
(See Flute Grinding Section)	
Forgings	
Centerless	97A601-K6-VFM
Cylindrical	97A601-J6-VFM
Gages (Thread)	
Grinding Threads	
12 pitch and coarser	9A100-K6-VFM
Grinding Threads 13-20 pitch	9A120-L6-VFM
Grinding Threads	
24 pitch and finer	9A180-N6-VFM
Gages (rings)	
Internal	
Roughing	9A60-L6-VFM
Finishing	9A100-I6-VFM
Fine Finishing	9A220-I4-VFM
Gears (Casehardened - Precut)	
18-20DP	9A120-I6-VA
5-18DP	9A80-J6-VA
2-5DP	9A60-I6-VA
Gears (Casehardened - from a solid)	
Finetooth	9A120-I6-VA
Gears (Cast Iron)	
Teeth	6C54-I6-VSC
Gears (Hardened Steel)	
Internal	97A601-K4-VFM
Surfacing (cups and cylinders)	9A36-I6-VFM
Surfacing (segments)	97A361-J6-VFM
Surfacing (discs) (remove burrs)	97A461-J9-B90
Surfacing	9A46-J6-VFM
Glass (circular mirrors)	
Rough Beveling (automatic)	5C80-K6-VSC
Rough and Final Beveling (automatic)	5C120-J6-VSC
Glass (cut glass)	
Concaving bottoms of tumblers	9A90-L6-VFM
Edging	6C180-N4-VSC
Glass (flat)	
Beveling	5C100-K6-VSC
Cutting-off	C2A601-R9-BF9
Glass (Globes)	
Grinding Edges	5C80-I6-VSC
Glass (Lenses)	
Edging - Machine	5C220-I6-VSC
Glass Tubing	
Centerless	5C180-J6-VSC
Cylindrical	6C46-I6-VSC
Internal	6C90-H6-VSC
Thin Wall (1A1R)	CMD220-R50-B
Glass (Tumblers)	
Edging - Lead Glass	6C120-P4-VSC
Edging - Lime Glass	5C150-J4-VSC
Granite	
Surfacing (Planer Wheels)	6C24-K9-B90
Molding	
7000-9500 SFPM	
Roughing	6C24-O9-B90
Finishing	6C60-M9-B90
Gun Barrels	
Spotting and O.D.	
Cylindrical	97A601-M4-VFM
Centerless	97A601-L6-VFM
Internal	
Grind Contours of Cartridge Chamber	9A60-L6-VFM
Hastalloy	
Surface	9A46-H6-VFM
Vertical Spindle	9A46-F10-VFM
Internal	97A541-L6-VFM
Cylindrical	9A54-K4-VFM
Centerless	97A541-K6-VFM
Inconel or Inconel X (with heavy duty soluble or straight oil)	
Surface	
Type 1 Wheel	9A60-H6-VFM
Vertical spindle	9A46-F10-VA
Form Grinding	97A601-I6-VFM
	97A601-J6-VFM

Cylindrical	9A60-J4-VFM
Centerless	6C60-K6-VSC
Thread	9A180-N6-VFM
Knives (Machine)	
Cutting-off (dry)	C2A461-M9-B90
Cutting-off (wet)	C2A461-M9-B90
Chipper and Barker, Sharpening	97A361-I6-VFM
Hog, Sharpening	97A361-J4-VFM
Leather Fleshing, Sharpening (Bricks)	97A361-P4-VFM
Leather Shaving, Sharpening	
Cylindrical	97A461-P7-B90
Molding, Offhand Sharpening	97A461-I6-VFM
Machine, Sharpening	97A461-I6-VFM
Paper, Sharpening	97A701-I6-VFM
Section, Beveling	97A461-M4-VFM
Surfacing Backs	97A461-I6-VFM
Veneer, Sharpening	97A601-I6-VFM
Veneer, Surfacing	9A46-I6-VFM
Limestone	
Surface (Drum Rubber)	6C36-L9-B90
Lawn Mowers	
Resharpening	97A601-M6-VFM
Leather	
Misc. Grinding	6C30-J6-VSC
Suede Finishing	6C60-M6-VSC
Lucite (centerless)	6C60-M6-VSC
Cutting-off (dry)	6C60-L9-B90
Cutting-off (wet)	6C60-L9-B90
Marble	
Surfacing (wheel)	
Roughing	6C24-M6-VSC
Finishing	6C60-K6-VSC
Molding - 5000-6500 SFPM	
Roughing	6C24-M6-VSC
Semi-Finishing	6C54-K4-VSC
Masonite	
Cutting-off	6C24-O9-B90
Meehanite (see Cast Iron)	
Metallized Materials (Sprayed Metal)	6C54-I6-VSC
Minerals - Lapidary	
Soft	
Roughing	6C100-N6-VSC
Finishing	6C220-L6-VSC
Hard	
Roughing	6C100-M6-VSC
Finishing	6C220-K6-VSC
Molybdenum	
Cylindrical	97A601-J6-VFM
Surfacing	97A461-I6-VFM

Monel Metal	
General Reinforced Cut-off	
Less than 16"	97A301-R7-BF9
16" and over	97A301-R7-BF9
Internal	6C60-J6-VSC
Cutting-off (dry)	97A301-R7-B2S
Cutting-off (wet)	2A24-P-R
Cylindrical	6C60-K6-VSC
Needles	
Pointing	97A1201-M4-VFM
Nickel Rods and Bars	
Cutting-off (dry)	97A461-P9-B90
Cutting-off (wet)	97A461-P9-B90
Ni Hard	
Centerless	97A601-K6-VFM
Cylindrical	97A801-K4-VFM
Internal	9A80-K6-VFM
Surfacing	
Wheels	9A46-I6-VFM
Segments	9A36-F10-VFM
Nitralloy (cylindrical)	
Before nitriding	9A60-H6-VFM
After nitriding	
Commercial Finish	9A60-I6-VFM
High Finish	6C100-I6-VSC
Reflective Finish	7C2201-I9-B90
Noroc	
Centerless	6C100-H6-VSC
Cylindrical	6C100-H6-VSC
Internal	6C100-H6-VSC
Surface	YC80-H6-VSC
Nylon	
Centerless	6C36-L6-VSC
Surfacing	97A361-L6-VFM
Pen Parts (centerless)	
Rubber	6C30-J6-VSC
Plastics	9A80-N6-VFM
Pen Points (iridium)	
Cutting-off	2A220-R9-B90
Pipe (Cast Iron)	
Cleaning	97A361-K9-B90
Pipe (Steel) Finish Unimportant	
Cutting-off (dry)	2A24-R9-B90
Cutting-off (wet)	2A24-R9-B90
Pipe Balls	
Centerless	97A361-P4-VFM
Regrind	97A361-P4-VFM
Pistons (Aluminum)	
Cylindrical	97A461-J4-VFM
Centerless	6C46-J6-VSC
Regrinding	97A461-I6-VFM
Pistons (Cast Iron)	
Cylindrical	5C46-J6-VSC OR 6C36-K6-VSC
Centerless	6C46-K6-VSC
Regrinding	97A461-I6-VFM

Piston Pins	
Centerless Machine	
Roughing	2A60-M6-VFM
	97A541-P7-B90
Semi-Finishing	97A601-N7-B90
	97A801-M6-VFM
Finishing	97A2201-N9-B90
Surfacing Ends (discs)	C2A54-I9-B90
Piston Rings (Cast Iron)	
Surfacing Rough (cylinders)	9A30-H6-VFM
Surfacing (discs)	
Roughing	6C24-K9-B90
Semi-finishing	5C46-I9-B90
Finishing	5C80-G9-B90
Surfacing	9A80-K6-VFM
Internal	6C46-M6-VSC
Piston Rings	
Plasma Spray - Carbides, Chrome)	
Centerless	
Roughing and Finishing	5C80-H6-VSC
Finishing	6C60-L6-VSC
Piston Rods (Locomotive)	
Cylindrical	2A46-M4-VFM
Plastics	
Cutting-off and Surfacing	2A36-K9-B90
Cutting-off (dry)	2A36-K9-B90
Cutting-off (wet)	2A36-K9-B90
Cylindrical	6C46-I6-VSC
Plexiglass	
Cut-off	2A36-K9-B90
Surfacing	2A36-K9-B90
Plumbing Fixtures (Vitreous)	
Disc	6C36-K9-B90
Polystyrene	
Centerless	6C46-J6-VSC
Cut-off	6C60-P9-B90
Porcelain	
Cutting-off	6C36-N9-B90
Cylindrical	5C80-K6-VSC
Centerless	5C80-I6-VSC
Propeller Hubs	
Internal	
Rough and Finish	9A60-J6-VFM
Fine Finish	97A1201-I4-VFM
Pulleys (Cast Iron)	
Cylindrical	6C36-J6-VSC
Roughing with Pulley Grinder (Cyl. Wheel)	6C24-J6-VSC
Finishing with Pulley Grinder (Cyl. Wheel)	6C60-J4-VSC
Race Grinding	
(See Microcentric and Chucking Grinder Section)	
Reamers	
Backing-off	9A54-J6-VFM
Cylindrical	97A601-K6-VFM
Regulating Wheel	
(See Centerless Grinding Section)	
Rene	
Surface (Form Grinding)	97A601-J6-VFM
Rexalloy (See Stellite)	29A801-J6-VA
Rocker Arm	
Internal	97A60-M4-VFM
Rods (Centerless)	
Miscellaneous Steel	97A60-M6-VFM
300 Series Stainless	6C54-N6-VSC
Nitralloy (before nitriding)	2A601-L6-VFM
Silichrome Steel	97A601-K6-VFM
	C2A54-R7-B90
Brass and Bronze	6C60-K6-VSC
Hard Rubber	6C30-K6-VSC
Carbon	6C36-N6-VSC
Plastic	9A80-N6-VFM
Rokide (Plasma Spray)	
All Operations	
Roughing (1A1, 2A2)	CMD150-N75-BY
Finishing (1A1, 2A2)	CMD400-N75-BY
Roller Bearing Cups	
Centerless O.D.	97A601-L6-VFM
Internal	97A801-L4-VFM
Rollers for Bearings	
Centerless - Roughing	97A801-L6-VFM
- Finishing	97A1201-P9-B90
Surfacing Ends (discs)	C2A101-I9-B90
Rolls	
See Roll Grinding in Centertype Section	
Roll Scouring Bricks	
Hot Mill Rolls	6C80-L6-VSC
Cold Mill Rolls	6C120-L6-VSC
Rotors (Laminated) (Cylindrical)	
Roughing	97A1001-I6-VFM
Finishing	C2A2201-J9-B90
Rubber (Soft)	
Cylindrical (dry)	97A241-L9-B90
Rubber (Hard)	
Cutting-off	6C46-K9-B90
Cylindrical	6C46-K9-B90
Rubber Hose	
Cutting-off (dry)	6C24-L9-B90
Cutting-off (dry, steel mesh)	6C46-O9-B90
Sand Cores	
Cutting-off (dry)	6C24-N9-B90
Saws	
See Toolroom Section	
Scissors and Shears (Cast Iron)	
Surfacing Sides or Blades	97A801-I6-VA

Scissors and Shears (Steel)	
Surfacing Sides of Blades	97A461-Q4-VFM
Grinding Flash from Bows	97A801-P4-VFM
Pointing and Shaping	2A120-O9-B90
Grinding Neck or Corner	97A1201-O4-VFM
Strike Cutting Edges	9A100-M6-VFM
Resharpening (small wheels)	9A100-K6-VFM
(large wheels)	97A901-M4-VFM
Shafts (centerless)	
Pinion	97A601-M4-VFM
	97A601-Q9-B90
Spline	97A601-O4-VFM
Shear Blades (Power Metal Shears)	
Sharpening (Segments)	9A46-I6-VA
Sharpening (Cylinders)	9A46-I6-VA
Shells (Ordnance)	
Centerless	2A60-M6-VFM
Silicon Nitride	
Surface and Cylindrical	
Roughing (1A1, 2A2)	MD100-N75-BY
Finishing (1A1, 2A2)	MD320-N75-BY
Silver	
Cylindrical	9A100-K6-VFM
Skate Blades	
Resharpening	97A801-K6-VA
Slate	
Cutting-off	6C36-P9-B90
Coping	6C46-M9-B90
Molding	6C54-K6-VSC
Spline Shafts	
Centerless	97A601-M6-VFM
Cylindrical	97A601-N4-VFM
Grinding Splines	97A601-L4-VFM
Sprayed Materials, (wet grinding)	
General Nickel, Chrome, Cobalt and Stainless Materials:	
Surface	5C46-H6-VSC
	9A46-H6-VFM
Cylindrical	5C60-J6-VSC
	9A60-J6-VFM
Centerless	5C60-J6-VSC
	9A60-J6-VFM
Internal	5C80-L4-VSC
	9A80-L4-VFM
Carbide, Zirconia, Tungsten, Alumnia, Airconte, High Cobalt and Titania Materials:	
Surface	7C541-I6-VSC
Cylindrical	7C541-J6-VSC
Centerless	7C601-J6-VSC
Internal	7C801-I60VSC
Sprayed Metal	
Internal	6C46-J6-VSC
Springs (Coil)	
Squaring Ends (discs)	
Small Gage Wire	C2A361-J9-B90
Medium Gage Wire	C2A361-J9-B9
Large Gage Wire	C2A241-I9-B90
Stainless (17-4HP) with heavy duty soluble or straight oil	
Surface	9A60-I6-VFM
	6C60-J6-VSC
Internal	9A46-J4-VFM
	6C46-K6-VSC
Cylindrical	9A60-K4-VFM
	6C54-K6-VSC
Centerless	29A601-K6-VFM
Steatite (Ceramic)	
Centerless	6C60-J6-VSC
Cut-off	6C80-M9-B90
Surfacing	6C46-J6-VSC
Steel Castings (Low Carbon)	
Internal	9A54-L6-VFM
External	97A601-J6-VFM
Steel Castings (Manganese)	
Surfacing	12A24-H10-VA
Internal (rough grinding)	97A361-L6-VFM
General Reinforced Cut-off	2A24-R7-BF9
Steel Forgings (discs)	
Small - light work	97A461-I9-B90
Large - heavy work	97A361-G9-B90
*Steel (Tool 55 Rc and harder)	
Cutter Sharpening	
Type 1A1	1BN120-T-B7
Cup Wheel	
roughing	1BN80-W-B7
finishing	1BN180-Q100-B4
Disc Wheel	1BN120-W-B7
	97A601-J9-B90
Surfacing	
Type 1 Wheel	1BN120-T-B7
Internal	
Mounted Points -	1BN120-Q100-B4
or	2BN120-R125-VHA
Type 1 Wheel	1BN120-Q100-B4

**For conventional recommendations refer to Tool Room Section. Also see Diamond and CBN Section.*

Steel *Hard) (Rc55 and harder)	
Centerless (fine finish)	97A1201-M4-VFM
Centerless (commercial finish)	2A60-K6-VFM
Centerless (regulating wheel)	A80-R-BR
Cylindrical (smaller wheels)	97A601-L4-VFM
Cylindrical (larger wheels)	97A541-L4-VFM
Internal	9A60-L6-VFM
	97A801-K4-VFM
Internal bearing	9A80-K6-VFM
Surfacing	9A60-H10-VA

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Steel (Hard) (Rc55 and harder) cont.	
Surfacing	
(cylinders, cups, segments)	
Broad Contact	9A36-E10-VFM
Narrow Contact	9A46-H6-VFM
Surfacing (discs - rough)	97A361-I9-B90
Surfacing (discs - finish)	97A461-G9-B90
Cutting-off	97A541-O9-B90
Steel (Soft) (Up to Rc55)	
Cut-off	2A46-R9-B90
Reinforced Cut-off	2A24-R7-BF9
Cylindrical	
Less than 1 diameter	97A601-M4-VFM
Over 1 diameter	97A541-L4-VFM
Disc	
Roughing	97A241-J9-B90
Finishing	97A461-I9-B90
Internal	97A461-M4-VFM
Surfacing	
Type 1 Wheel	9A36-K6-VFM
Cylinders, Cups, Segments	9A24-G10-VA
Steel (Stainless - 300 Series)	
Centerless	97A541-K6-VFM
Centerless (Regulating Wheel)	A80-R-BR
Cylindrical	9A46-J6-VFM
Internal	9A46-I6-VFM
Surfacing (Type 1 Wheel)	9A46-J6-VFM
Surfacing (cups and cylinders)	9A30-H6-VFM
Surfacing (segments)	9A46-F10-VA
Surfacing (form grinding)	97A601-I6-VFM
	97A601-J6-VFM
Cutting-off	6C46-Q9-B90
Steel (Stainless)	
General Reinforced	97A301-R7-BF9
	97A301-T7-BF9
Steel (High Speed)	
Centerless (commercial finish)	97A601-K6-VFM
Centerless (fine finish)	97A801-I6-VFM
Centerless (regulating wheel)	A80-R-BR
Cylindrical (14 and smaller)	97A601-L4-VFM
Cylindrical (16 and larger)	9A60-K4-VFM
Internal	9A80-K6-VFM
	9A46-H6-VFM
Surfacing (type 1 wheels)	9A60-F10-VFM
Surfacing (cups & Cylinders)	9A46-G6-VFM
Surfacing (segments)	9A46-H6-VA
Cutting-off	97A461-O9-B90
Cutting-off (tubing)	97A541-Q9-B90
Steel	
(Stainless - 400 Series Hardened)	
Centerless (commercial finish)	97A601-K6-VFM
Centerless (fine finish)	C2A801-N9-B90
Centerless (regulating wheel)	A80-R-BR
Cylindrical (14 and smaller)	97A601-L4-VFM
Cylindrical (16 and larger)	97A541-K4-VFM
Internal	97A601-K6-VFM
Surfacing (type 1 wheels)	9A46-I10-VA
Surfacing (cups & cylinders)	9A36-G50VFM

Steel	
(Stainless - 400 Series Hardened) cont.	
Surfacing (segments)	9A24-G10-VA
Surfacing (form grinding)	97A601-I6-VFM
	97A601-J6-VFM
Cutting-off (dry)	C2A601-R9-B90
Stellite (also Rexalloy, Tantung)	
Cylindrical	97A461-M4-VFM
Cutter Grinding	9A46-J6-VFM
Surfacing (cups, cylinders)	9A46-G6-VFM
Surfacing (discs)	97A361-J9-B90
Surfacing (straight wheels)	9A46-H6-VFM
Cutting-of	6C46-R9-B90
Stove Parts (Cast Iron)	
Surfacing Tops Automatic	
Roughing	6C36-Q6-VSC
Finishing	6C80-Q6-VSC
Surfacing (discs)	C2A241-I9-B90
Tantalum	
Cylindrical	97A601-K6-VFM
Surfacing	97A461-J6-VFM
Tantung (see Stellite)	
Tappets (centerless)	
Steel	
Roughing	97A601-O4-VFM
Finishing	97A801-N6-VFM
Cast Iron	
Roughing	6C46-N6-VSC
Finishing	6C80-M6-VSC
Taps	
(also see Tool Room Section)	
Fluting (small taps)	2A100-W-R
(large taps)	2A100-U-R
Grinding Relief	9A60-K6-VFM
Squaring Ends	97A601-N6-VFM
Threading	
Precut	
2 through 6	9A80-J6-VFM
8 through 12	9A100-K6-VFM
14 through 24	9A150-L6-VFM
Taps	
Threading	
Solid	
4 through 12	9A100-K6-VFM
14 through 20	9A120-L6-VFM
24 through 36	9A180-N4-VFM
40 and finer	9A220-N4-VFM
Shanks (cylindrical)	97A801-M6-VFM
Tile	
Cutting-off	6C36-O9-B90
Disc	6C36-I9-B90

Titanium	
Precision Grinding Surface	9A60-J6-VFM
	5C60-J6-VSC
Vertical Spindle	5C60-J6-VSC
Internal	5C60-J6-VSC
Cylindrical	6C60-J6-VSC
Centerless	6C54-L6-VSC
Thread	7C2201-R9-B90
Rough Grinding	7C601-Q9-B90
Tools - Single Point	
See Tool Room Section	
Carbon & High Speed Steel	
Roughing	97A361-O4-VFM
Finishing	97A601-M4-VFM
Tools - Single Point	
Wet Tool Grinders	
12 to 24" diameter wheels	97A361-M4-VFM
Over 24" diameter wheels	97A241-M4-VFM
Machine Grinding	
Type 1 Wheels	
15" Diameter wheels	97A361-L4-VFM
24" Diameter wheels	97A241-M4-VFM
Cup or Cylinder wheels	97A241-L6-VFM
Tool Steels	
(See Tool Room Grinding Section)	
Tubing, Steel	
Centerless	97A601-K6-VFM
Cutting-off	
Steel	97A601-K9-B90
Stainless Steel	C2A60-M9-B90
Chrome - Molybdenum	C2A60-M9-B90
Tubing (Cut-off)	
Brass, Bronze	C2A601-R9-B90
Tungsten	
Cylindrical	
Rolled Tungsten	9A54-L4-VFM
Sintered Tungsten	6C60-J6-VSC
Centerless	
Rolled Tungsten .	9A46-N4-VFM
Sintered Tungsten	6C60-K6-VSC
Surfacing - 2000 SFPM	97A461-J6-VFM
- 6000 SFPM	6C46-J6-VSC
Tungsten Carbide (see Carbide)	
Udimet	
Surfacing (Form Grinding)	97A601-I6-VFM
	97A601-J6-VFM
Valves (Automatic)	
Refacing	6C80-N6-VSC
	97A801-J4-VFM
Stems	
Cylindrical	97A601-N4-VFM
Centerless	97A601-M6-VFM
Cutting-off	97A601-R9-B90
Surfacing Ends (discs)	97A461-J9-B90
Valve Lifter Bodies	
Internal	97A901-M6-VFM
Valve Seat Inserts - Regrinding	
Roughing	
Cast Iron	6C80-M6-VSC
Alloy Steel	9A80-M6-VFM
Stellite	9A80-K6-VFM
Finishing	
All Seats	6C150-L6-VSC
Valve Seats (steel)	
Internal	9A70-P4-VFM
Valve Tappets	
Centerless	97A801-M6-VFM
Cylindrical	97A541-M4-VFM
Vascaloy - Ramet	
(see Cemented Carbide)	
Vitallium	
Cylindrical	9A60-J6-VFM
Surfacing	9A60-I6-VFM
Waspalloy (with straight oil)	
Surface	
Form Grinding	97A601-I6-VFM
	97A601-J6-VFM
Type 1 Wheel	9A46-I6-VFM
Vertical Spindle	9A46-F10-VFM
Internal	9A60-J4-VFM
Cylindrical	9A60-J4-VFM
Centerless	97A601-J6-VFM

Important — The wheel gradings listed in this section are general starting recommendations. They should not be considered as optimum for the listed jobs.

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HELPFUL HINTS FOR PROBLEM SOLVING:

	ADJUST AND/OR INCREASE COOLANT	CHECK DIAMOND	CHECK DRESSING RATE	CHECK FEED RATE	CHECK PART HARDNESS	CHECK WHEEL FOR PROPER CLAMPING	CHECK TAILSTOCK AND CENTERS	CHECK WHEEL AND WORK RPM	MAKE SURE WHEEL IS CLEANED UP	BALANCE WHEEL	CHECK MAIN COOLANT SUPPLY	CHECK COOLANT ON DIAMOND	CHECK WHEEL GRADING
BURN	✓	✓	✓	✓	✓						✓	✓	✓
CHATTER		✓	✓	✓		✓	✓	✓	✓	✓			✓
FINISH	✓	✓	✓	✓	✓			✓	✓	✓	✓		✓
OUT OF ROUND	✓	✓		✓		✓	✓	✓	✓	✓			✓

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